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NWU Self-Directed Learning Series

Volume 11

Problem-based learning and pedagogies of play

Active approaches towards Self-Directed Learning

Edited by

Marietjie Havenga, Jako Olivier & Byron J Bunt

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Peer-review declaration

The publisher (AOSIS) endorses the South African 'National Scholarly Book Publishers Forum Best Practice for Peer-Review of Scholarly Books'. The scholarly book proposal form was evaluated by our Social Sciences, Humanities, Education and Business Management editorial board. The manuscript underwent an evaluation to compare the level of originality with other published works and was subjected to rigorous two-step peer-review before publication by two technical expert reviewers who did not include the volume editors and were independent of the volume editors, with the identities of the reviewers not revealed to the editors or authors. The reviewers were independent of the publisher, editors and authors. The publisher shared feedback on the similarity report and the reviewers' inputs with the manuscript's editors to improve the manuscript. Where the reviewers recommended revisions and improvements, the editors responded adequately to such recommendations. The reviewers commented positively on the scholarly merits of the manuscript and recommended that the book be published.

Research justification

The focus of this book is original research regarding the implementation of problem-based learning (PBL) and pedagogies of play (PoPs) as active approaches to foster self-directed learning (SDL).

With the Fourth Industrial Revolution (4IR) in mind, educational institutions need to rethink teaching and learning for the future. As such, active engagement can be encouraged, as evident in this book, where PBL drives learning through real-world problems, while PoP focuses on innovative environments where the action of play and learning are integrated with the aim of developing SDL.

The following are addressed in the chapters: an overview of PBL and PoP, metaliteracy, playful PBL tasks, computational thinking in game-based tasks and geometry, solving puzzles, applying LEGO®, using drama as the PoP and implementing educational robotics (ER). The empirical research findings disseminated in this book aim to inspire academics in the research focus area of SDL with active learning approaches in the school and tertiary classroom that hold affordances to enhance 21st-century skills. Active learning is an umbrella term for pedagogies that mainstream student engagement, such as PBL, cooperative learning, gamification, role-play and drama. This scholarly book highlights various engaging pedagogies.

Initially submitted abstracts were screened by a scientific committee. All chapters were submitted, and put through Turnitin for plagiarism detection, and the editors screened them before being submitted to AOSIS Scholarly Books, which performed similarities, overlaps and plagiarism checks via iThenticate, following a rigorous peer-review process. The editors are confident that the book comprises a valuable scholarly discourse that will consequently contribute to the scholarship on PBL, PoP and SDL. In addition, we confirm that no part of the book has been plagiarised.

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Contents

Abbreviations and acronyms, boxes, figures and tables appearing in the text and notes

List of abbreviations and acronyms

ACM	Association for Computing Machinery
AMR	Academy of Management Review
AI	artificial intelligence
AOE	anti-oppressive education
AoO	apprenticeship of observation
ARCS	attention, relevance, confidence and satisfaction
AREF	Regional Academy of Education and Training
BA	Bachelor of Arts; bachelor's degree
BEd	Bachelor in Education degree
BODMAS	bracket, order, division, multiplication, addition and subtraction
BSc	Bachelor of Science degree
CANRAD	Centre for the Advancement of Non-Racialism and Democracy
CAPS	*Curriculum and Assessment Policy Statement*
CC	Creative Commons
CG	control group
CHAT	cultural-historical activity theory
CIL	*Communications in Information Literacy*
CL	cooperative learning
CMS	content management system
CoE	Chair of the Centre for Excellence
COIL	collaborative online international learning
CoL	Commonwealth of Learning
COMBER	Community-Based Educational Research
CRS	corporate responsibility standards
CSCL	computer-supported collaborative learning
CT	computational thinking
CTOOL	Computational Thinking at School
DA	Dramatic Arts

DBE	Department of Basic Education
DBP	drama-based pedagogy
DDP	dialogical drama with puppets
DGBL	digital game-based learning
DHET	Department of Higher Education and Training
DSEA	Conference on Disability, Arts and Education
EASA	Education Association of South Africa
ECD	early childhood development
ECE	early childhood education
EduREC	Research Ethics Committee of the Faculty of Education
EFAL	English First Additional Language
EG	experimental group
EHL	English Home Language
EITT	educational innovation through technology
ER	educational robotics
ETR&D	Educational Technology Research and Development
FOSS	free and open-source software
GBL	game-based learning
GIF	graphic interchange format
HE	higher education
HEI	higher education institution
HL	Home Language
HOT	higher-order thinking
HoTS	higher-order thinking skills
ICDE	International Council for Open and Distance Education
ICECE	International Conference on Electrical and Control Engineering
ICESCO	Islamic World Educational, Scientific and Cultural Organization (formerly ISESCO)
ICT	information and communication technology
ICTs	information and communication technologies
IDE	integrated development environment
IEB	Independent Examination Board
IEEE	Institute of Electrical and Electronics Engineers
IP	intellectual property
IRGEE	*International Research in Geographical and Environmental Education*
ISTE	International Society for Technology in Education
IT	information technology

ITEA	Institutional Teaching Excellence Awards
LAN	local area network
LED	light-emitting diode
LMS	learning management system
LoLT	language of learning and teaching
LoTS	lower-order thinking skills
LTM	long-term memory
MA	Master of Arts degree; master's degree
MASARA	Musical Arts in South Africa: Resources and Applications Research Unit
MEd	Master of Education degree
MDE	mechanics, dynamics and aesthetics method
MIT	Massachusetts Institute of Technology
MOOC	massive international open online courses
MP	multilingual pedagogies
MR	mixed reality
MRTEQ	Minimum Requirements for Teacher Qualifications
MS	Microsoft
MtL	motivation to learn
NABT	National Association of Biology Teachers
NRF	National Research Foundation
NSC	National Senior Certificate
NW	NB, Zolkipli, MZB, Wei
NWU	North-West University
NY	New York
OECD	Organization for Economic Cooperation and Development
OER	open educational resource
OERs	open educational resources
PBL	problem-based learning
PERMA	positive emotions, engagement, positive relationships, meaning and achievement/accomplishment
PFC	prefrontal cortex
PGCE	Postgraduate Diploma in Education
PHEAPC	High Energy Physics, Astronomy and Computational Physics
PhD	Doctor of Philosophy degree; doctoral degree
PISA	Programme for International Student Assessment
PoP	pedagogy of play
PoPs	pedagogies of play
PPBL	playful problem-based learning

PPC	person-process-context
R&D	Research and development
RADLA	Research and Doctoral Leadership Academy
RAMP	relatedness, autonomy, mastery and purpose
RAS	Russian Academy of Sciences
RRT	reader-response theory
SAICSIT	South Africa Institute of Computer Scientists and Information Technologists
SCERT	State Council of Educational Research and Training
SCT	social-constructivist theory
SDL	self-directed learning
SDT	self-determination theory
SoTL	Scholarship of Teaching and Learning
SPOC	small private online course
SPSE	School of Professional Studies in Education
SRL	self-regulated learning
SRSSDL	Self-rating scale of self-directed learning
STEAM	science, technology, engineering, art and mathematics
STEAMIE	science, technology, engineering, arts, mathematics, innovation and entrepreneurship
STEM	science, technology, engineering and mathematics
SUNY	State University of New York
TEL	technology-enhanced learning
TERA	Teaching and Education Research Association
TRCN	Teacher Registration Council of Nigeria
UCA	Cadi Ayyad University
UK	United Kingdom
UKZN	University of KwaZulu-Natal
UNAL	Universidad Nacional de Colombia
UNECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIR	Universidad Internacional de La Rioja
UWC	University of the Western Cape
VR	virtual reality
WCI	writing and critical inquiry
WIL	work-integrated learning
WM	working memory
ZPD	zone of proximal development

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Foreword

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This scholarly book explores the nexus of engaging pedagogies and self-directed learning (SDL). When I was asked to write the foreword for this much-needed book, I was reminded of the insights of two authors. The first was the wisdom of John Slaughter, quoted in Chmielewski and Stapleton (2009, p. 53), who stated that 'research is to teaching what sin is to confession; if you don't participate in the former you have very little to say in the latter'.

The empirical research findings disseminated in this book will hopefully inspire practitioners to experiment with more active learning approaches in the school and tertiary classroom that hold affordances to enhance 21st-century skills. The second author that came to mind was Tytler (2007), who – fifteen years ago already – stated that there is a genuine mood for change to re-imagine education to suit today's world. The world is rapidly changing, and education should change with it. We live in a world where artificial intelligence (AI) is becoming more important. One example is the social humanoid robot Sophia, developed by Hong Kong-based company Hanson Robotics, which became the first robot to attain citizenship in a country (Saudi Arabia).

Research tells us that transmission-mode approaches still plague many South African classrooms. This often leads to student disengagement, highlighting the need for active learning approaches. Active learning is an umbrella term for pedagogies that mainstream student engagement, such as problem-based learning (PBL), cooperative learning, gamification, role-play and drama. The chapters in this book highlight various engaging pedagogies where the learners, as *Homo ludens* [the playing human] (Huizinga 1955), engage with the learning content. The role of play in the learning process was very central in the work of Lev Vygotsky (1978). Veresov (2004) refers to the 'hidden dimension' of Vygotsky's work that escaped social-constructivist scholars for decades. Although most Vygotskyan scholars explain scaffolding of learning across the zone of proximal development (ZPD) by referring to the 'inter-psychological' and 'intra-psychological' categories, a fundamental aspect of Vygotsky's work was missing in the discourse. Veresov traces the construct of 'categories' back to pre-revolutionary Russian theatre. Learners first construct

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knowledge together (the 'inter-psychological category'), after which internalisation occurs (the 'intra-psychological level'). However, as Veresov (2004, p. 14) shows, the word 'category' in the Russian-theatre context actually meant 'a dramatic event, a collision of the characters on stage'. Firstly, the roots of Vygotsky's work can be found in play and drama. Secondly, the conflicts – or what Veresov (2004) refers to as 'dramatical collisions' – are scaffolds that could lead to powerful and deep learning. I was delighted to see that role-play and drama are also receiving attention in this book, and this gives further momentum to the new drive of speaking of STEAMIE (science, technology, engineering, arts, mathematics, innovation and entrepreneurship) education, in contrast to the previous STEM (science, technology, engineering and mathematics) approaches. Research shows that role-play holds affordances to assist critical reflection and facilitate conceptual (deep) understanding (Sogunro 2004).

A corpus of research shows that problem-based and cooperative learning approaches could enhance SDL. In the complex 21st century in which we live, SDL should be enhanced to ensure that people develop the skills to adjust to an ever-changing world. The chapters in this book provide a holistic perspective on SDL by focusing on the different dimensions in the person-process-context (PPC) model of Hiemstra and Brockett (2012). Light is shed on the personal attributes that should be underpinning the self-directed learner ('person' dimension), the affordances of engaging pedagogies during teaching and learning ('process'), as well as the context that best facilitates SDL, for example, confronting the learner with an authentic, real-life problem that should be investigated.

The research contribution of this book to the transformed knowledge project is significant, as it alerts the reader to consider the affordances of engaging pedagogies for developing SDL in the era of the Fourth Industrial Revolution (4IR). This complex era, characterised by rapid changes in molecular biology and gene editing, AI, advanced robotics and changes in societal patterns, asks for creative and critical thinking. This book's leitmotif is that young learners, used to social media and gamification, would gain much from engaging pedagogies. It poses a challenge to the schooling sector and higher education institutions (HEIs) to rethink their pedagogies. The chapters – both through empirical data and systematic literature reviews – provide a 'thick description' (Geertz 1973) that illuminates the complexity of teaching and learning in a complex 21st century.

Preface

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This academic book focuses on scholarly research contextualising innovative learning and knowledge construction by applying active teaching–learning practices such as problem-based learning (PBL) and pedagogy of play (PoP) to enhance self-directed learning (SDL). In support of the rationale of this book, PBL and pedagogies of play (PoPs) are discussed in terms of SDL in some theoretical chapters, followed by several chapters reporting on authentic learning practices in various disciplines. This book focuses on practices where students develop SDL abilities to thrive in the 21st century by utilising the abovementioned strategies and contributing to essential skills for future demands. Moreover, this focus supports the aim of this book: Exploring the convergence of PBL, PoP and SDL within the school classroom and higher education (HE) contexts.

The rationale for this book relates to the increasing need for effective ways to support the development of self-directedness within different educational contexts. Despite SDL being regarded as an intuitive activity, it is evident that not all learners act effectively in this way (Lapidow & Walker 2022). As the broader discourse on PBL has shown, PBL can improve critical thinking skills, problem-solving and the development of SDL (Manuaba, No & Wu 2022). Consequently, the proposed approach in this book relating to PBL is essential for the 21st-century classroom and the skills required in this dynamic and evolving context. Similarly, employing SDL shows a mediating effect as a critical requirement for PBL (Song, Lee & Lee 2022).

As PoPs are also considered explicitly in this book, it is important to note that increased use and availability of technology allow for opportunities around the role of play in the learning process. In this book, this aspect of play is explicitly approached in terms of PoP. From the literature, overtly supporting PoP through the integration of authentic play experiences may support student–teacher advocacy and the support of PoP in their own

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classrooms in the future (Galbraith 2022). It is also clear that play and, by implication also, PoP are essential in different areas of development of learners (Galbraith 2022). The rapid rise in interest and use of digital gaming also supports the increased relevance of PoP in the educational sphere while considering the relevant critical game literacies required (Coopilton 2022). As evident from empirical research, such gamification strategies also support learners' SDL (Palaniappan & Noor 2022). In order to explore the intersections between PBL, PoP and SDL further, this book brings together ten unique chapters approaching these topics conceptually and empirically from different angles.

A short overview of the relevant chapters is presented to unpack this book's focus further. In Chapter 1, PBL is outlined as an innovative teaching and learning strategy that enables students to develop 21st-century skills and SDL abilities. According to this chapter, strategies such as PoP can be integrated to foster critical and creative thinking and problem-solving. In playing certain types of games, the players need to solve ill-structured problems with similar learning conditions and outcomes as PBL.

In the second chapter, the notion of 'Pedagogy of play' emphasises the educational benefits of play by arguing that play describes the two essential principles at the foundation of education: Spontaneous and natural direction, on the one hand, and intention, on the other hand. This chapter outlines the theoretical foundation of PoP and the links to developing SDL. Furthermore, the chapter delineates the various PoP strategies, such as puppetry, drama and storytelling, game-based learning (GBL) and gamification, as well as LEGO® and robotics.

The third chapter focuses on metaliteracy and emphasises the reflective and self-directed individual through domains of learning, learner roles and characteristics, as well as goals and learning objectives. These components offer opportunities to highlight problem-based PoP as mechanisms of learning and engagement. Following the conceptual exploration of the relationships amongst PoPs, SDL, PBL and metaliteracy, the authors examined multimodal pedagogies of play where these connections are evident.

With the focus on playful problem-based learning (PPBL), Chapter 4 emphasises that educators in such environments must cultivate a positive attitude towards fostering SDL skills within each student's capacity so that learning can be experienced as meaningful. Furthermore, within these PPBL environments, educators must create fun, authentic and meaningful learning opportunities that will enable students to thrive.

Chapter 5 relates to PPBL and highlights the development of computational thinking (CT) as an essential skill for the Fourth Industrial

Revolution (4IR). The notion of CT involves various thought processes associated with solving real-world problems based on the attributes of computer science. This chapter investigates the active engagement of mathematics education students in *Scratch* game-based tasks to develop their CT skills. In addition, some affordances related to CT were the development of several SDL skills.

Geometry remains a challenge for the majority of learners from primary school onwards. In Chapter 6, learners are motivated to develop their abstractions and concretise their knowledge of geometry for SDL. Problem-based pedagogical sequences were developed in coding based on the LOGO pedagogical environment. Moreover, fostering SDL via coding can be optimised through learner involvement, leading to improvements in their abstractions, which finally develop their mathematical skills.

In Chapter 7, the authors present a design approach to address the issue of moving from and to verbal representations by using learner-generated puzzles with the help of interactive simulations for learning linear equations. Puzzles can be a great source of learning mathematics. The learners created puzzles independently and posted them on the interactive platforms for their peers to solve. The ability to create and solve puzzles independently has strong elements of self-directedness.

Chapter 8 relates to the application of LEGO® to promote SDL. In realising the need to align teacher-training with the development of critical 21st-century skills, the authors provided for the inclusion of the LEGO® Foundation's Six BRICKS initiative activities as part of our teaching practice curriculum for first-year students. Through various engaging LEGO® activities, students were guided in PBL, PoP and SDL as they dealt with the real-world challenge of professional identity formation.

Chapter 9 focuses specifically on drama-based pedagogy (DBP) as a form of PoP as a vehicle to promote student learning of concepts and principles, as opposed to direct instruction of facts and concepts. This chapter focuses on implementing DBP as an intervention for poetry studies in a multicultural Grade 12 classroom and promoting SDL and learners' motivation in learning.

Finally, Chapter 10 aims to provide insight into the study of educational robotics (ER) for PPBL using third-generation cultural-historical activity theory (CHAT) as a research lens. Educational robotics is essential for developing digital skills, critical thinking and collaborative problem-solving, initiative, autonomy and CT. Teacher-training programmes should expose pre-service teachers to ER to support and prepare them to acquire content and pedagogical knowledge and provide professional development opportunities.

With the 4IR in mind, education institutions must rethink teaching and learning for active, innovative involvement in this field. As such, as is evident in these chapters, active engagement can be encouraged by implementing PBL and PoPs, as evidenced in this book. This book contributes to the scholarship of SDL with the integration of PBL and PoP and recommendations on how these strategies can enhance SDL for future challenges that may arise.

Chapter 1

Problem-based learning: A 21st-century teaching and learning strategy

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Abstract

Active learning embedded in constructivism has been associated with developing higher-order thinking skills (HoTS). In the literature, special mention is made of problem-based learning (PBL) that can cultivate, foster and develop HoTS in higher education institutions (HEIs) and schools, as learning is focused on real-world problems. However, educators and teachers must ensure they know what PBL entails before implementing it in their subjects. This conceptual chapter aims to provide an overview of PBL to foster meaningful learning.

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Introduction

Problem-based learning enables university students and school learners to develop 21st-century skills, such as self-directed learning (SDL), problem-solving, critical thinking, collaboration and communication (Hussin, Harun & Shukor 2019, p. 20; Koh et al. 2019, p. 18). Problem-based learning follows a social-constructivist approach where students construct their knowledge through finding solutions to real-world, ill-structured problems in a collaborative learning environment (Scheer, Noweski & Meinel 2012, p. 8). As PBL focuses on problem-solving skills, other teaching and learning strategies, such as pedagogies of play (PoPs), can integrate a PBL approach to help foster meaningful learning (Kek & Huizer 2017, p. 31). In PoPs, the learners who acted as players need to find solutions to problems with similar learning conditions and objectives as PBL (Pyle & Danniels 2017, p. 277).

In a PBL environment, student learning centres on a 'real-world problem with more than one solution' (Savin-Baden 2008, p. 8). The teacher in a PBL environment acts as a facilitator or guide to assist the PBL process, using appropriate methods and scaffolds. However, with time, the facilitator should use fewer scaffolds and challenge the students to learn independently (Schmidt, Rotgans & Yew 2011, p. 797). In this conceptual chapter, PBL will be discussed in detail concerning the historical development of PBL, definitions of PBL, the PBL process, PBL formats, PBL and SDL, roles of the facilitator and students in PBL tutorials, scaffolds in PBL, assessment in PBL, different types of PBL problems, PBL and PoPs, as well as the advantages and challenges of PBL. It is necessary to point out that a literature review involving researching, reading, analysing and summarising scholarly literature about PBL was done through computer-accessible databases.

Historical development of problem-based learning

Problem-based learning originated nearly six decades ago as an alternative to direct lecture-centred instruction in medical education (Loyens, Magda & Rikers 2008, p. 412). To overcome the perceived challenges and failings of the traditional direct instruction approach, McMaster University in Hamilton, Ontario, Canada, implemented PBL as an innovative active teaching and learning approach to medical education (Tan 2005). As highlighted by Barrows (2000), the reason for this was that a traditional, direct lecture-centred instructional approach did not contribute to developing students' HoTS (Albanese & Mitchell 1993, p. 52). The implementation of PBL emphasises a shift from passive to active learning.

Therefore, the student takes responsibility for their learning, while the lecturer or teacher would fulfil a facilitation role. Moreover, with the implementation of PBL, students would have to search for information in problem-based scenarios, whereafter lecturers could assess their abilities to use theoretical knowledge to formulate solutions to a problem. It was necessary to develop PBL activities to optimise student learning experiences (Barrows 2000). It was clear that PBL would promote learner-centred multidisciplinary education (Barrows & Tamblyn 1980), helping to foster lifelong learning and SDL (Hussin et al. 2019, p. 20).

Problem-based learning has expanded to subject areas such as pharmacy, engineering, nursing, law, business education, mathematics and science in higher education (HE) (Kong et al. 2014, p. 459; Walker & Leary 2009, p. 12), as well as physical therapy, advertising and architecture (Zakaria, Maat & Khalid 2019, p. 2672). However, the implementation of PBL in teacher education and school education has only gained momentum over the last few decades (Borhan 2014, p. 76; De Simone 2014, p. 17; Golightly 2018, p. 460; Golightly & Muniz 2013, p. 432; Morgado & Leite 2013, p. 2343). In a South African context, PBL was introduced to HEIs and colleges from European and American tertiary institutions (Dolmans et al. 2005, p. 734).

Definition of problem-based learning

In literature, various definitions of PBL are reported. Torp and Sage (2002) state that PBL focuses on research, discussions and solving real-world problems. Similarly, MacDonald and Savin-Baden (2004, p. 13) state that in PBL the emphasis is on organising the module content, focusing on case studies or scenarios, while Savery (2006, p. 9) defines PBL as a method that requires formulating sound or practical solutions to some real-world issues through doing self-directed research for information. More recent definitions of PBL describe it as an approach that uses problems to encourage students to acquire knowledge of a discipline or subject (Lapuz & Fulgencio 2020) or as a learner-centred teaching and learning approach that challenges students to do a self-directed search of sources, and then apply their acquired knowledge to formulate possible solutions to a real-world problem (Corrêa & Martins 2016, p. 159). This chapter will refer to the definition of Torp and Sage (2002).

Key features of problem-based learning

Problem-based learning promotes active learning in a social-constructivist setting where students construct their own knowledge by working collaboratively in PBL groups (Allen, Donham & Bernhardt 2011, p. 22).

Salinitri, Wilhelm and Crabtree (2015, p. 74) as well as De Graaff and Kolmos (2003, p. 658) highlight some of the key features of PBL, including that students must solve real-world problems to foster meaningful learning, collaborate in small groups, are supported by facilitators, and participate in self-directed research and self-study to find solutions to real-world problems.

In PBL, the problems should be ill-structured, meaning that the problem must have multiple solutions or answers (Hmelo-Silver & Barrows 2006, p. 24; Sockalingam 2015). The problems must be authentic, challenging and complex (Hmelo-Silver, Duncan & Chinn 2007, p. 100) and mainly in the form of real-world PBL scenarios or case studies (Selçuk 2015, p. 4). Through the solving of problems, the students acquire the necessary knowledge and understanding of the content (Savin-Baden 2008, p. 8). Tan (2005) and Ellingsen et al. (2021) point out that the use of cross-disciplinary knowledge to provide solutions to the problem is also a prominent characteristic of PBL and that students must take into consideration knowledge from various disciplines, subjects and topics.

As mentioned earlier, in PBL environments, learning is student-centred (Selçuk 2015, p. 3). Another PBL feature is that students have to collaborate in their PBL groups, where they engage as problem-solvers and work together towards addressing the formulated learning issues to provide solutions to the stated problems (Torp & Sage 2002). In their respective PBL groups, the group members must determine what the problem is, then formulate learning issues, get involved in self-directed research, use the self-researched information to provide solutions to the problem and then do self-assessment as to whether they achieved the learning issues (De Simone 2014, p. 18). The importance of collaborative learning environments is that they can give rise to the multiple perspectives, views and ideas of group members that can contribute to the formulation of more realistic and meaningful solutions (Hmelo-Silver et al. 2007, p. 101).

The problem-based learning process

In the literature, researchers state that there are various approaches to the PBL process. In this section, reference will be made to the 'Seven Jump' approach that was developed by Schmidt and Moust (2000):

- **Step 1:** Identify the concepts and ensure learners understand the stated problem.
- **Step 2:** Ask questions about the problem so that the learners understand the problem better.
- **Step 3:** In their PBL groups, learners discuss what they know and do not know about the problem.

- **Step 4:** Analyse and organise the group discussion findings in Step 3.
- **Step 5:** Formulate the learning objectives for further self-directed research.
- **Step 6:** All group members collect information through an independent search for resources.
- **Step 7:** Discuss the findings of the group members and provide possible solutions to the stated PBL.

Kek and Huijser (2011, p. 336) distinguish between three stages in the PBL process aligned with Schmidt and Moust's (2000) PBL process steps. The first stage includes the analysis of the problem and then formulating the learning objectives to assist students in solving the problem. The second research stage allows group members to do self-directed research for independent learning, whereafter they apply their knowledge in the PBL tutorial sessions. During these sessions, group members must assess and reflect on their knowledge in solving the problem. During the third stage, group members share their information with the other group members. Group members must assess their learning performance and contribution to the PBL activity.

Problem-based learning formats

In literature, different PBL formats or models are reported in tertiary institutions. However, in this chapter, reference will be made to pure, hybrid and integrated PBL formats. In the *pure PBL* format, PBL is implemented throughout the entire curriculum. In this format, a skillful facilitator guides and supports students collaborating in PBL groups. The group members are expected to apply SDL in solving the stated problem (Savin-Baden 2008, p. 10).

In a *hybrid PBL* format, traditional teacher-centred 'instructional methods, such as mini-lectures and demonstrations' are used to guide group members in solving the problem (Carrió et al. 2016, p. 2). The inclusion of the mini-lectures and demonstrations by the facilitator can be seen as scaffolds to provide support to the group members during the PBL process (Fukuzawa, Boyd & Cahn 2017, p. 182).

In an *integrated PBL* format, PBL is embedded in a teacher-centred instructional curriculum for a few days or weeks and can be either a pure or a hybrid format (Golightly 2018, p. 464; Kivela & Kivela 2005, p. 437).

Problem-based learning and self-directed learning

In PBL, SDL is often seen as a core element (Schmidt et al. 2011, p. 38). However, it is necessary first to define the concept of SDL. In literature, one of the most well-known definitions for SDL is that of Knowles (1975), who defines SDL as:

> A process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. (p. 18)

In this regard, Francom (2010, p. 30) points out that SDL students must be able to formulate their learning intentions by implementing learning strategies and self-directed research of resources to assess and reflect on their learning. Unsurprisingly, Savery (2015, p. 8) points out the fostering of students' SDL skills when implementing PBL, as they are challenged to take ownership of their own learning (Bidokht & Assareh 2011, p. 1446). Some of the PBL features that promote the enhancement of students' skills to learn on their own are highlighted by Hmelo and Lin (2000) and Loyens et al. (2008, p. 413), namely that PBL environments are characterised by their learner-centredness, problem-solving, formulation of learning issues, self-directed search for knowledge, self-study, self-assessment and monitoring and collaboration between group members.

From the literature, it is also clear that the PBL formats can influence students' SDL skills differently. A pure PBL format is more likely to improve students' development of SDL skills compared to other PBL formats, where the facilitator provides the group members with more support and guidance (Lee, Mann & Frank 2010, p. 426). In literature, most studies have been reported with pure PBL curricula to foster students' SDL skills (Gadicherla et al. 2022, p. 975; Koh et al. 2019). However, the evidence regarding the influence of the integrated PBL format on students' SDL skills is inconclusive. In this regard, Walker and Lofton (2003, p. 71) report a decrease in PBL students' SDL scores, Golightly and Guglielmino (2015, p. 73) found no real influence of PBL on students' SDL scores, while Aziz et al. (2014, p. 135) found an increase in students' SDL scores.

Regarding the impact of hybrid PBL on students' SDL skills, Lee et al. (2010, p. 434) found no influence on students' SDL skills after implementing a hybrid PBL intervention. At the same time, Benadé (2020) and Mulaudzi (2021) report that hybrid PBL positively influenced some students' SDL skills.

■ The role of facilitators and students in problem-based learning tutorials

In a PBL environment, the lecturer fulfils the role of a facilitator and should plan and design real-world ill-structured problems that can help achieve the set lesson objectives (Woods 2006). The facilitator supports, facilitates and inspires group members to embrace the PBL process (Savery 2019) and effectively assists students in collaborating in their groups (Goh 2014, p. 163). To achieve this, the facilitator must develop procedural guidelines that promote group interactions and collaboration within PBL tutorial sessions (Chuan et al. 2011, p. 397). The facilitator, through questioning and didactic conversations in the various PBL groups, fosters students' metacognitive thinking skills (Goh 2014, p. 163; Savery 2019, p. 88). They can, if necessary, provide group members with relevant resources that can assist them in solving the stated problem (De Simone 2014, p. 19). With time, the facilitator should provide less guidance and assistance until members can learn on their own (Hmelo-Silver & Barrows 2006, p. 24). In this regard it is essential that the facilitator must be able to guide and assist members and know when to withhold feedback and guidance to develop members' SDL skills (Ertmer & Glazewski 2019).

It is expected of the facilitator to evaluate the members' progress and to assess their PBL reports and presentations (De Simone 2014, p. 19). In PBL environments, the facilitator must assist members in managing their learning time so that they submit the PBL tasks by the deadline (Grant 2011, p. 52) and create a good learning community between the facilitator and students. Against this background, Lockspeiser et al. (2008, p. 368) highlight three characteristics of the facilitator that can improve students' learning in a PBL environment: being an expert in their field, as well as social and cognitive congruence. Facilitators with sufficient subject knowledge can provide effective support and guidance and ask relevant questions during the tutorial sessions. Regarding social and cognitive congruence, it is essential that the facilitator shows interest in their students' well-being and a desire for them to succeed. The facilitator should have the skills to communicate on a level the students will understand.

In PBL environments, the students are actively involved in the learning process and become 'active constructors of their knowledge' (Dahms & Zakaria 2015). The focus is on collaboration and good communication between group members in tutorial sessions (Grant 2011, p. 63). Students collaborate in groups of four–six (Kolmos 2008). After the members receive the problem, they must formulate the learning issues. Afterwards, each group member must do individual self-directed research to find relevant resources online or in the library. Group members must then share and discuss their researched findings with fellow members. This interaction between members is vital as it can contribute to the development of problem-solving, critical thinking, collaboration and communication skills (Koh et al. 2019, p. 18). It is also necessary for members to be involved in self- and peer-assessment to monitor what they have learnt and each group member's contribution to solving the problem (Savery 2015).

Scaffolds in problem-based learning environments

In PBL environments, students must learn on their own to enhance their SDL skills. However, the facilitator still plays an essential role in designing a PBL environment to support and guide students during the learning process (English & Kitsantas 2013, p. 130; Varadarajan & Ladage 2022, p. 159). Therefore, the facilitator must use various scaffolds that support students in their groups to successfully achieve the learning issues (Ertmer & Glazewski 2015; Yeung 2010, p. 196).

Different scaffolds will be used in the students' different learning contexts and can take various forms (Simons & Klein 2007, p. 44). In literature, a distinction is made between hard and soft scaffolds (Ertmer & Glazewski 2019). Hard scaffolds provide assistance, support and guidance with possible challenges that members may experience in solving the problem (Choo 2012; Moallem & Igoe 2020). These scaffolds may include student guides, training PBL videos, prescribed learning materials or resources, guiding templates, worksheets and assessment rubrics (Choo 2012; Yeung 2010, p. 192). Interestingly, students usually consult most of the intricate scaffolds before beginning the PBL activity (Choo 2012). In contrast, soft scaffolds in PBL environments provide in-the-moment support and guidance during the tutorial sessions, such as discussions and debates between the different role-players (Moallem & Igoe 2020; Schmidt et al. 2011, p. 797). During the PBL tutorial sessions, the soft scaffolds include the facilitator's comments on the group's performance, asking pertinent questions, offering suggestions, hints and clues to assist them in solving the problem (Preus 2012, p. 59), and promoting collaboration among members (Caesar et al. 2016, p. 56). Interestingly, in his study, Golightly (2021b, p. 12) reports that 'pre-service geography teachers in a South African context rated soft scaffolds as having a greater impact on their learning compared to hard scaffolds'.

Assessment in problem-based learning

Assessment should be planned as an integrated part of all activities to ensure that it is embedded throughout the PBL process. Savery (2019) states that assessment in PBL should be both knowledge- and process-based. Therefore, the integration and development of various assessments of, for and as learning strategies are important in providing feedback on students' and learners' subject knowledge and skills, as well as mastery of higher-order cognitive skills (Lu, Bridges & Hmelo-Silver 2014, p. 299).

In the assessment of learning, the facilitator mostly uses an assessment rubric to identify students' 'core competencies and essential skills', including 'attitude and punctuality, preparedness, participation, knowledge, group skills, problem-solving skills, critical thinking and the relevance of resources' (Ibrahim & Al-Shahrani 2018, p. 84). Assessment of learning tasks used by a facilitator can take the form of assessing group members' contribution and performance in solving the problem (Sim et al. 2006, p. 636), the PBL report compiled by the group, the PBL portfolio of a group member or a presentation of the stated solutions that generally occur following submission of the report. The assessor must collect evidence to either compare or numerically rate the group members (Albanese & Hinman 2019, pp. 398–404).

Assessment for learning is the assessment process that is being integrated with the PBL process and supporting and guiding each member's learning (Schuwirth & Van der Vleuten 2011, p. 478). The formative assessment informs group members on how to adjust learning strategies to improve the future acquisition of knowledge through solving the stated problem (Li & De Luca 2014, p. 378). The facilitator gives feedback on the groups' performances, explicitly referring to members' preparation for a tutorial session, formulating and clarifying learning issues, knowledge about the problem, communication, attitude, working in groups, leadership and self-assessment skills (Mubuuke, Louw & Van Schalkwyk 2016; Siarova, Sternadel & Mašidlauskaitė 2017, p. 37). Feedback can help to develop a member's ability and skills to learn on their own (Clark 2012, p. 217). Albanese and Hinman (2019, p. 393) point out that assessment rubrics are important tools in providing feedback to students in PBL environments.

As students are responsible for their learning in PBL contexts, it is important to involve them in the assessing process (MacDonald & Savin-Baden 2004, p. 8). Therefore, in assessment as learning, the members are responsible for assessing their and their peers' performances and contributions in solving the problem (Siarova et al. 2017, p. 40), to challenge group members to develop their monitoring and self-assessment skills (Koh et al. 2019, p. 19) and improve their metacognitive skills. Therefore, facilitators must equip members with critical assessment skills to give feedback on their learning and contributions to PBL using assessment rubrics or checklists (Sridharan & Boud 2019, p. 900).

Different types of problem-based learning problems

Solving problems in real-world contexts is significant in PBL (Sebatana & Dudu 2022). As a problem initiates the learning process, the quality of problems is crucial for meaningful learning (Sockalingam & Schmidt 2011).

According to Van den Hurk et al. (1999), the quality of the problems has an influence on the formulation of relevant learning objectives as well as students' self-directed activities. A problem must be situated in real-life contexts, which allows students to construct their own meaning, consequently linking the prescribed curriculum content within their contexts. A PBL problem must be inherently interdisciplinary (Brassler & Dettmers 2017; Gallagher et al. 1995) so that learners can apply some of the content pieces of knowledge from various subjects and disciplines. According to Jonassen (2011), when designing a PBL problem, aspects to consider include structure, difficulty and context based on the characteristics of students. In this regard, the author identified the following problems as ill-structured, namely 'decision-making problems, troubleshooting problems, diagnosis-solution problems, situated cases/ policy problems, design problems and dilemmas' (Jonassen 2000, p. 76). Interestingly, Jonassen and Hung (2008) concluded that 'decision-making problems should be used as the problem focus of PBL' (Jonassen & Hung 2008, p. 21). An example of a PBL decision-making problem is presented by Golightly (2018):

> South Africa is a water-scarce country and we need to manage water properly. To encourage the different municipalities to improve the quality of drinking water and water sources, the Department of Water Affairs annually awards Blue and Green Drop status to municipalities for the effective treatment and monitoring of drinking water, as well as the management of responsible water consumption and maintenance of services. The Tlokwe municipality (Potchefstroom) has for the past few years received the Blue as well as the Green Drop award. However, the question remains as to the quality of the water in the Mooi River in Potchefstroom. The local newspaper asks you, as geography student, to determine the water quality of the river by using miniSASS [*sic*.] and, if necessary, to make recommendations to the local government on how to improve the river's water quality. (p. 465)

■ The design of problems

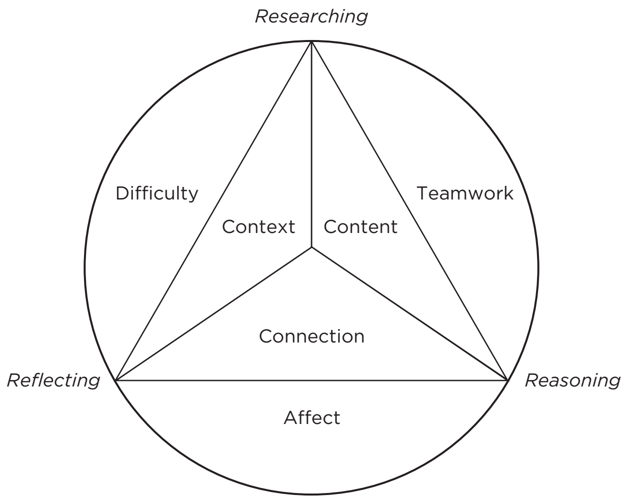
One of the important knowledge areas to possess about PBL is designing such problems (Sockalingam 2015). In this regard, Dolmans et al. (1997) list several principles to plan and design problems, these being that PBL problems should relate to the real world, promote collaboration between group members, promote knowledge integration, foster SDL, deal with students' prior knowledge, evoke students' interest and reflect the educational institution's objectives. Hung (2019) also points out that ineffective PBL problem designs can lead to insufficient content knowledge coverage by the students when solving the problem.

The Stanford University Newsletter on Teaching (2001, p. 4) outlines four steps or phases in formalising the PBL problem: Step 1: *Exploration* *or experimentation*, where the problem is presented to the students. Step 2: *Sustainability*, where the problem is revised after learners' feedback. Step 3: *Institutionalisation*, which refers to whether the problem is meaningful for the industry or the subject area. Step 4: *Reinvention*, where changes are made to the problem so that it keeps up with new information, topics and developments in the domain.

The findings of Sockalingam and Schmidt (2011) show that students believed that the problem's title must be aligned with the learning objectives and that the students must be familiar with the problem context. They further state that the problem can have keywords and pictures to provide further support and guidance to the students in solving the stated problem. Sockalingam and Schmidt (2011, pp. 18–19) conceptualised their study findings into two groups: 'feature', which refers to the problem's design elements, and 'function', which refers to desired learning objectives when solving the problem.

According to Sockalingam and Schmidt (2011, p. 20), the PBL characteristics refer to 'characteristics that are the design elements of the problems. Characteristics such as problem format, clarity, familiarity, difficulty, and relevance (application and use) are the design elements of problems'. The problem format states how the facilitator presents the problem to the group members because problems may use known phrases (in science, which might be principles, theories or laws), scenario texts, pictures or cartoons, and interactive simulations. Problem clarity concerns whether the problem highlights hints and clues of the intended content for teaching and learning, while familiarity pertains to whether the problem is aligned with students' prior knowledge and interests (Dos Santos 2017). Another feature characteristic concerns the level of difficulty of a PBL problem – which must be suitable for the students' level and the depth to which intended content must be taught and learnt (Hung 2019). The PBL problem must also be of relevance for students' application, either in the classroom for a better conceptualisation of the content or in their day-to-day activities (Dos Santos 2017).

Concerning the functional features of a good problem, it is necessary for the problem to stimulate and promote students' critical reasoning, SDL, elaboration and teamwork, and it must assist in achieving the identified learning objectives (Dos Santos 2017; Sockalingam & Schmidt 2011, p. 20). In other words, a PBL problem must help promote the 4C's – critical thinking (for reasoning), collaboration (teamwork), communication (elaboration) and creativity (achieving learning objectives) – to provide good solutions to the stated problem. The other functional characteristic is SDL, where students take responsibility for their learning, aligning with Knowles's SDL definition (Robinson & Persky 2020).



Source: Hung (2019, p. 251).

FIGURE 1.1: The second generation of the 3C3R problem-based learning design model.

Hung (2006) proposes a conceptual framework for problem design as a theoretical 3C3R model. More recently, Hung (2019) refined his 2006 model and called it 'The second generation of the 3C3R PBL problem design model' (see Figure 1.1).

The second generation 3C3R model represents three core components: 'core, processing and enhancing' (Hung 2019, p. 252). Regarding Figure 1.1, the core components refer to 'content, context, and connection', which refer to 'the students' content and conceptual learning', while the process components, namely 'researching, reasoning, and reflecting' (see Figure 1.1), refer to the students' thinking processes and skills in solving real-world problems (Hung 2019, p. 252). Enhancing components comprise affect, difficulty and teamwork. According to Hung (2019), enhancing components may influence individual motivation, engagement, SDL and shared learning. Regarding core components, the PBL problem must show the intended content and its connection with the context in which students are exposed. The process components suggest that the PBL problem must encourage students to research additional information and use their reasoning skills and critical reflection to solve it.

Advantages and challenges of the implementation of problem-based learning

In literature, various studies highlight the advantages of PBL. Some of the most important advantages of PBL will be discussed in this section.

In this regard, Koh and Chapman (2019) point out that PBL promotes real-world learning of disciplinary content knowledge and professional competence. Ali (2019) and Baran (2016) report that PBL facilitates the acquisition of content knowledge and the fostering of 21st-century skills (Hussin et al. 2019, p. 20; Kek & Huijser 2017, p. 31). In other studies, González (2019) states that PBL increases students' motivation to learn, while Gilbert and Afonso (2015), Lee et al. (2010, p. 425) as well as Golightly (2021a) state that effective implementation of PBL activities enhances students' SDL skills.

However, with the implementation of PBL, it can be expected that there will be challenges for the facilitator and students. In this regard, Wood (2008) mentions that the effective implementation of PBL may be a challenge, as well as the design and planning of good PBL problems and activities. In addition, the Stanford University Newsletter on Teaching (2001) states that planning and designing PBL problems can be time-consuming but can also assist and support students in achieving their learning goals. According to Aker and Pentón-Herrera (2020), Ceker and Ozdamli (2016) and Dillon et al. (2018), the implementation of PBL can be time-consuming, while Wijnen et al. (2017, p. 4) point out that the new learning environment can be challenging for lecturers and students. Poor implementation of PBL can affect the students' learning in PBL environments and counter the positive advantages of PBL to foster students' HoTS.

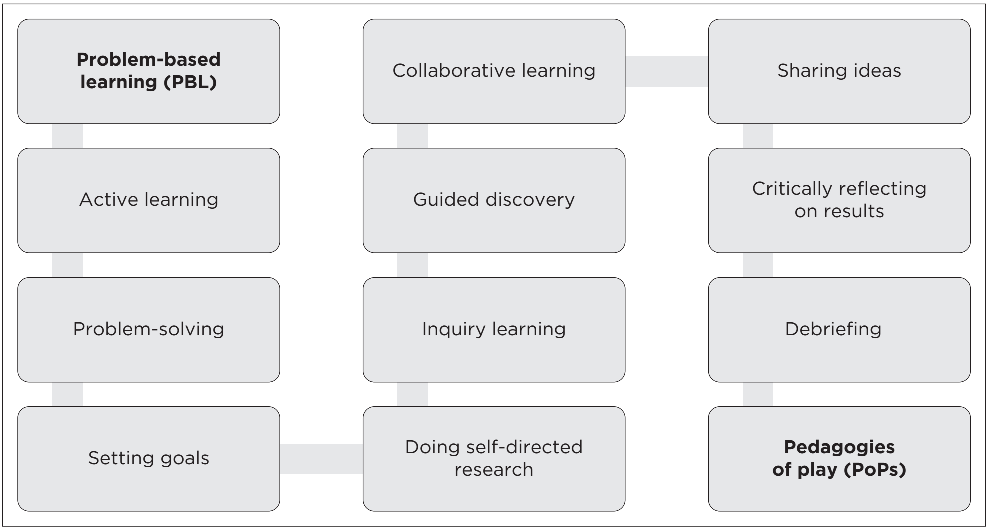
Other challenges can include teachers' resistance to implementing PBL in their classrooms as it increases their workload (Li 2013; Yarnall & Ostrander 2011). Another challenge that may hinder the implementation of PBL is teachers' lack of knowledge and understanding of PBL and how to implement it effectively in the curriculum (Li 2013; Naji et al. 2020). Practically, PBL requires teachers to have the necessary facilitation skills and access to venues and rooms where students can work in their PBL groups (Bestetti et al. 2014).

Some studies also report that collaborative learning in PBL groups can hinder meaningful learning for some group members. Some members may not contribute to some tasks, as it is difficult to assess each group member's contribution to the PBL activity (Golightly 2021a; Golightly & Muniz 2013). It is necessary to highlight that some students may struggle to work in groups with others, while others struggle to decide what is essential to learn in a PBL environment (Mansor et al. 2015). In this regard, the effective use of self- and peer-assessment of learners' contributions in PBL environments can help to solve some of the challenges members experience in PBL activities (Golightly 2021a). For some students, it will be challenging to do self-directed research and find and investigate rich learning materials and resources (Tandoğan & Akinoğlu 2007, p. 74). However, it is essential to mention that it will take time for lecturers, teachers and students to get used to the new role they must fulfil in PBL.

Problem-based learning and pedagogies of play

As PBL focuses on problem-solving skills, other teaching and learning strategies, such as PoPs, including game-based learning (GBL), digital games, drama-based pedagogy (DBP), puzzle-based learning and robotics, can integrate a PBL approach to help foster meaningful learning (Pyle & Danniels 2017, p. 277). In PoPs, the learners, who act as players, can be expected to solve problems with similar learning conditions and outcomes as PBL. Therefore, PoPs mostly consist of a learner-centred exploration of phenomena through playing a game, building a robot or performing (Pyle & Danniels 2017, p. 274). In these learning environments, the teacher can act as the facilitator (Walker & Shelton 2008). In some PoPs, the players can set goals to overcome an obstacle or solve a problem by interacting with fellow players. In playing a physical or digital game, building a robot, solving a puzzle or performing a drama play, the learners will be actively involved in the learning process (Pyle & Danniels 2017). In this regard, Kiili (2007, p. 394) identifies some of the important PBL features that must be included in these PoPs, namely, solving a problem or a challenge, active learning, collaboration and engaging with fellow students, learners setting learning goals, doing self-directed research, the facilitator providing scaffolding and feedback, content knowledge integrated around problems, students reflecting on their learning and the facilitator providing a debriefing at the end of the learning process (see Figure 1.2).

Some studies in educational, digital and entertainment games reported that learners develop more effective problem-solving skills in learner-centred PoP environments than in more formal, teacher-directed settings (Arnott 2016, p. 285). Therefore, it is no surprise that Huang, Hew and Lo (2019, p. 1106) believe that PoPs, with specific reference to educational games, digital games and entertainment games, should be designed to include various activities to create an interesting experience and ultimately lead to meaningful learning. In a study by Shahbodin et al. (2013, p. 8), the researchers used a combination of PBL and GBL in mathematics education to assist students in mastering mathematics knowledge. Chang, Chung and Chang (2020, p. 2615) and Darling-Hammond et al. (2020) report that the PBL approach to game-based and play-based learning can develop meaningful, active, engaging and socially interactive learning, enhancing satisfaction and enjoyment of the learning process. They further state that PBL games provide facilitators with an effective teaching and learning strategy to foster students' learning satisfaction in computer programming.



Source: Authors' own work.
Key: PBL, problem-based learning; PoPs, pedagogies of play.
FIGURE 1.2: Important problem-based learning features in pedagogies of play.

Flood, Heath and Lapp (2015) also highlight that in video- and computer-based games, students must find multiple solutions to a problem.

In literature, educational robotics (ER) can provide an authentic learning context for real-life applications, and problems can encourage active learning in various educational environments (Barker et al. 2012). Unsurprisingly, Ortiz (2011) states that using robotics can positively influence learners' problem-solving skills, while Witherspoon et al. (2016) also state that using robotics can improve social interactions between learners and the application of knowledge.

In two other PoPs strategies, namely drama-based learning and puzzle-based learning, the integration of a PBL approach can foster meaningful learning. For example, Duman and Özçelik (2018) pointed out that a PBL approach can be used in creative drama play to help achieve the set learning outcomes. The authors reported that the PBL approach followed in performing a creative drama play which positively affected learners' self-efficacy abilities. While puzzle-based learning inherently solves a problem, the aim is to get learners to find solutions to unstructured problems (Michalewicz, Falkner & Sooriamurthi 2011) and, in the process of learning, help develop learners' thinking skills and problem-solving skills (Costa 2017).

It is necessary to point out that this chapter provided an overview of PBL and referred to some of the important PBL features in PoPs.

However, in Chapter 2, the theoretical foundation of PoPs (such as puppetry, drama and storytelling, GBL and gamification) and its integration with PBL and SDL will be discussed in detail.

Conclusion

This chapter's main purpose was to give an overview of PBL. Implementing PBL in HEIs and schools can contribute to students' and learners' abilities to apply their understanding to real-world situations and where they will be able to solve 21st-century problems. However, to effectively implement PBL in programmes, curricula or modules, lecturers and teachers must be certain of what PBL is all about before implementing it in their classrooms. It is vital to inform the students and learners what PBL entails before lecturers and teachers introduce them to PBL. The importance of the design and planning of good problems, the role of the teacher and learners in PBL environments, the self-directed research for resources and materials, and the integration of various assessment methods are some of the most important features of PBL. Although students are actively involved in the PBL process, it is of utmost necessity that facilitators can provide the necessary scaffolds to guide the students in the PBL process. The implementation of various assessment methods that are aligned with the PBL principles is of importance. In a PBL environment, the facilitators must take note of the advantages and challenges of PBL before they implement PBL activities in their modules. Interestingly, because of the problem-solving nature of PBL, it is no surprise that PoPs can implement a PBL approach during the learning process to help foster meaningful learning.

Chapter 2

Pedagogy of play: A framework for self-directed learning

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Abstract

The pedagogy of play (PoP) places a focus on the learning advantages of play by asserting that play exemplifies the two fundamental principles at the heart of education: unintentional, unstructured exploration and intentional, purposeful action. The role of play in children's learning and development is one of the cornerstones of early childhood education (ECE). Theory and ideology may be traced back to early childhood development (ECD) programmes in a wide range of nations, including the United States of America (USA). Despite the many studies that have been conducted on learning via play, there has been surprisingly little investigation into the efficacy of using play in the classroom. Free play and individual preference have always complicated efforts to draw parallels between play and learning. Notwithstanding recent theoretical and legal developments, it is now increasingly vital to comprehend the

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diverse goals and nature of play in educational settings, as well as the role of instructors in preparing for and being playful in child-initiated or teacher-directed activity. In this chapter, the focus is on the theory behind PoPs and how it may be used to pave the way for self-directed learning (SDL), puppetry, drama, storytelling, game-based learning (GBL), gamification, LEGO® and robotics are just some of the strategies that will be outlined in this chapter. In conclusion, a novel framework will be explained that links SDL with PoPs.

Introduction

The concept of PoP, as per Lindqvist (1996), became more ‘segregated’ into specified locations and time slots in many Western countries as the 20th century came to an end. It was not until after school and on the playgrounds that learners could have fun and study (Baumer 2013). For teachers (and parents), the division of children’s play should be organic and safeguarded by these designated ‘spaces’, as per Nilsson (2009). Wood (2014) argues that play may be started by children, adults or policymakers, depending on the context. Instead of encouraging creativity and imaginative play, commercial toys, objects and material culture have taken the role of teachers’ (and parents’) participation in learners’ (and their children’s) play (Arnott & Yelland 2020).

Pedagogy of play promotes collaborative play between adults (teachers or parents) and children in the 21st century, which contrasts with the general tendency (Baumer 2013). When learners begin to play in the classroom, teachers deliver diverse resources, including emotional, cognitive, social and linguistic ones. In the classroom, learners’ knowledge, imagination, playfulness and improvisational skills are all put to the test, resulting in a distinctive teaching–learning interaction (Miyazaki 2010). Most crucially, a number of studies have shown that an increasing number of scholars are dedicated to creating PoP to aid in teaching crucial 21st-century skills (e.g. Boyle et al. 2014; Dondlinger 2007). Scholars are paying increasing attention to the concept of 21st-century skills, which encompasses a wide range of abilities, including those related to learning and innovation, namely, critical thinking, creativity, collaboration and communication, as well as information, electronic media and technology (Binkley et al. 2014) (e.g. Chan & Yuen 2014; Gee 2007). The primary goal of this chapter is to explain the conceptualisation of PoP and the various strategies that constitute playful learning. The chapter further seeks to link SDL and PoP, as they have natural connections. This chapter is conceptual in nature. The following section pays specific attention to PoP and its theoretical foundations, the most significant of which is SDL.

Pedagogy of play

Theoretical foundations and development

There are two key aspects in the teaching of play, which are both natural and deliberate: (1) spontaneous and natural and (2) intentional (Danniels & Pyle 2018; Farné 2005). The deliberate part of any PoP is generally focused on creating and administering playful activities and resources for learners with specific objectives in mind by a teacher (Farné 2005). To be sure, it is not just about playing games: PoP looks at everything that goes into a play experience from the perspective of its potential and material circumstances, as well as how meaning is formed in settings particular to the game (Farné 2005).

Gunilla Lindqvist invented the term 'pedagogy of play' in the 1980s (Baumer 2013; Lindqvist 1996). Based on Vygotsky's cultural perspective on learners' play, Lindqvist stressed the necessity of play teaching in the classroom (Baumer 2013). Learners who practice self-control during play will be better able to focus on their studies, according to Vygotsky (1978). He thought play was important because it provided different learning experiences that allowed learners to acquire new knowledge (Vygotsky 1967). Vygotsky's zone of proximal development (ZPD) theory states that learners can move beyond their ZPD because PoP helps them experiment with features and behaviours prevalent in their real-world experiences but rarely tested in the classroom.

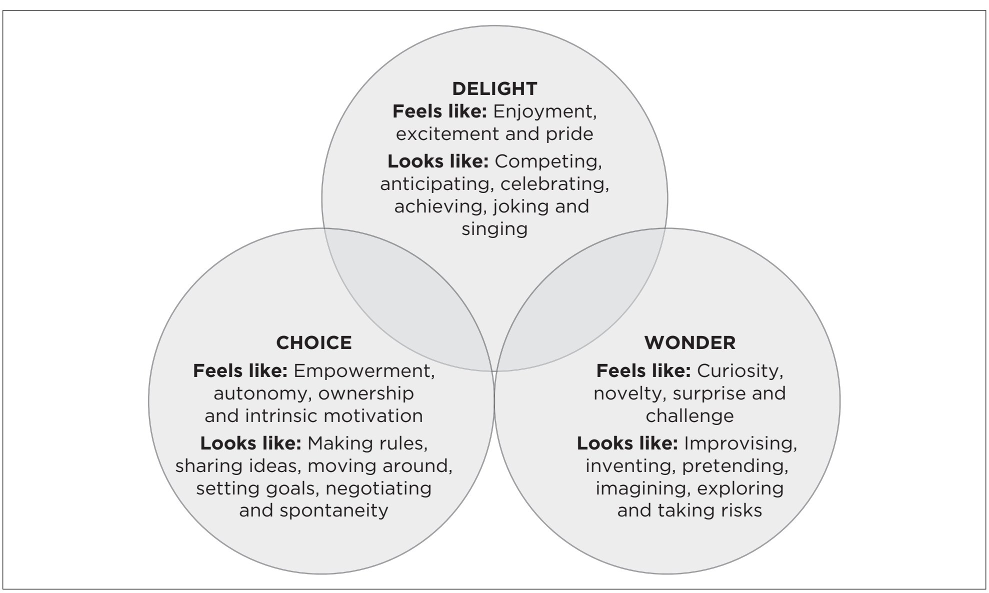
There are many inventive ways to educate and study in the classroom, and PoP is one of them (Vogt et al. 2018). Various games, such as board and card games, indigenous games (like 'Morabaraba'), puppetry or even video-gaming may be used to teach learners (Bendixen-Noe 2010; Brits, De Beer & Mabotja 2016; Nkopodi & Mosimege 2009; Vogt et al. 2018). Learning in PoP is easy for learners and students because they do not fear any impediments (willing to accept the challenge), and the information is kept and absorbed over time, as per Remer and Tzuriel (2015). Any play pedagogy that hopes to be effective must enable students and learners to participate in the learning process by having fun. Considering the characteristics of playful learning, one can tell whether the learner is engaged by noting the subsequent sub-sections.

Characteristics of playful learning

A clear picture of what PBL looks like is a critical first step in developing a play-based pedagogy. Both own experiences and those of others, such as theories and perspectives from relevant literature, have helped shape the design of the playful learning indicators that have been developed (Plass et al. 2020).

The definition of these criteria is a work in progress; nonetheless, what is developing is a paradigm of playful learning that incorporates criteria that are divided into three classifications: delight, wonder and choice (Plass et al. 2020). They are intended to characterise the quality of learners' experiences as they go through comprehension, knowledge and skill development stages. In order to account for the fact that fun learning has both subjective and objective aspects, the indicators indicate both psychological states and behavioural manifestations (Whitton 2018). Playful learning is most likely occurring when all three categories are 'in play', as depicted by the confluence of the circles in the diagram in Figure 2.1.

The sensation of freedom, independence, control, spontaneity and intrinsic drive that the playful learner experiences are all part of the *choice* process. Depending on their circumstances, learners may have these sentiments on their own or in a group (Whitton 2018). Collectively making decisions and the associated sensation of belonging to something greater than oneself may help people feel more empowered and in control of their lives. Learners displaying choice, in the eyes of an observer, are choosing objectives, creating and exchanging ideas, creating and altering rules, and managing obstacles (Plass et al. 2020). They are also expected to select collaborators and responsibilities, determine how long they will work or play, and determine when they will move about (Shelley et al. 2019). These are closely linked to SDL, which will be expanded upon further in this chapter.



Source: Author's own work.

FIGURE 2.1: Playful learning characteristics.

The realities for children (and, in many cases, adults) is that they seldom have total control over their lives. In schools, there might be conflicts between learner's interests and the aims of adult learning that can occur (Shelley et al. 2019). Most importantly, the perception of choice allows learners to have a sense of autonomy and ownership; they believe they have options to do what they want when they are allowed to do so (Whitton 2018).

Intrigue, originality, amazement and difficulty are all elements of the *wonder* experience, and they may engage and captivate the learner in various settings (Shelley et al. 2019). If you are an observer, a feeling of wonder entails experimenting and investigating, producing and inventing, pretending and envisioning, and pushing boundaries or learning via trial and error. The ordinary may be transformed into the exceptional via the power of wonder. It is possible to feel a sense of amazement by exploring objects, ideas, viewpoints, music, symbols, words, languages, tales, dance or other ways of expression (Plass et al. 2020).

Excitement, pleasure, contentment, motivation, expectation, confidence and a sense of belonging are all feelings associated with delight. Happy learners may show it by smiling, laughing, making jokes or being foolish (Plass et al. 2020). They could sing, hum or dance, and have a sensation of *hygge*, a Danish concept that refers to spending quality time with close companions in a comfortable setting. It is possible that they have narrowed their emphasis. Playful rivalry, celebration or participating in an unselfish deed may all provide opportunities to feel delighted.

Researchers are not saying that we do not take our teaching seriously by saying that learning can be fun. Taking education seriously does not mean, however, that learning should be devoid of enjoyment, happiness and pleasure (Shelley et al. 2019). It is indeed regrettable that schools lack a feeling of joy (Whitton 2018). Related to these characteristics of playful learning is the broader learner-centred theories that directly link to any PoP, the core of which is SDL.

■ Methodology

This chapter is fundamentally conceptual (Hirschheim 2008; Jaakkola 2020) rather than experimental in nature (Gilson & Goldberg 2015), thus offering a novel conceptual contribution to the application of PoP as an SDL approach.

In choosing between the different avenues conceptual research can take, namely theory synthesis, adaptation theory, typology and model papers (Jaakkola 2020), the researchers considered this study as a model paper. Conforming to the guidelines of a model paper, the researchers attempted to establish a theoretical framework for connecting ideas (concepts or constructs) (Jaakkola 2020). The authors included a representation of the concepts (constructs) of interest in the study (PoP and SDL), their observable manifestations and the interrelationships between these (Delbridge & Fiss 2013; Jaakkola 2020; MacInnis 2011; Meredith 1993). Additionally, the author unravelled and discovered a novel link (Cornelissen 2017; Fulmer 2012; MacInnis 2011) that advances existing knowledge concerning the use of a teaching approach, namely PoP, to assist teachers in applying SDL in their classrooms.

In order to answer the research question, namely, how can PoP assist in the development of SDL, the author employed a scoping review (Arksey & O'Malley 2005). According to Arksey and O'Malley (2005), scoping reviews summarise current literature and findings from completed research and are used when a research topic is not yet well understood or to identify knowledge gaps (Munn et al. 2018), as in the case of the present study.

As reporting the results of the scoping review was not the primary goal of the current study (Peters et al. 2015), only three of the six stages proposed by Arksey and O'Malley (2005) were used to guide the scoping review: (1) In defining the research question, (2) locating relevant studies and (3) selecting the best studies.

Theories linked to pedagogies of play

In light of the increased popularity of learner-centred teaching and learning, existing education pedagogies that concentrate on promoting learner autonomy, primarily via play, have resurfaced. Self-determination, social-constructivist theory, self-directed and self-regulated learning (SRL), problem-based learning (PBL) and cooperative learning (CL) are some of the approaches that constitute these pedagogies. Self-directed learning relies heavily on these pedagogies because of how they foster learner agency via the medium of play. In what follows, we will examine different pedagogies from the student's perspective and how they relate to the concept of independent study.

Self-determination

Defined by Ryan and Deci (2002), the concept of self-determination refers to the fact that humans have a drive for continuous self-improvement, both independently by regulating their own actions and in respect towards other individuals within social contexts. It is hypothesised that the human urge for self-improvement stems from three basic needs: 'Competence, relatedness, and autonomy' (2002, p. 6).

Motivation, self-regulation, learner autonomy, goal-setting and self-efficacy are all important aspects of Ryan and Deci's (2002) theory. However, heutagogy incorporates additional principles, such as self-reflection and metacognition, double-loop learning (i.e. adapting one's objectives or criteria for making decisions based on past performance), learner competency and capability, and neuroscientific proof – is the prefrontal cortex's (PFC) control mechanisms that choose and manage goal-relevant information in the learning process – in conjunction with working memory (WM) and long-term memory (LTM) of how we learn (Blaschke 2012; Blaschke & Hase 2016, 2019; Guy & Byrne 2013; Hase & Kenyon 2013).

Social constructivism

According to social constructivism, knowledge is gained through moving from the familiar to the unfamiliar (Olson & Hergenhahn 2009; Omodan 2022). Dron and Anderson (2014, p. 43) pose that 'the learning process is distinct and dynamic, as well as personal and contextual', 'depending upon their (the learner's) individual and communal understandings, histories, and tendencies'. Learners are at the heart of the constructivist approach, which is defined by characteristics such as active and genuine learning, scaffolded learning and collaborative learning (Harasim 2017). Incorporating contextual factors into learning activities, encouraging knowledge production, including diverse views, and encouraging interdependence, conversation, engaging interaction, exploration and problem-solving are all important to fulfil the main purpose of learning (Dron & Anderson 2014; Jonassen et al. 1995). Pedagogy of play, where the instructor plays more of a facilitator role, scaffolds the learning process and leads the learner or student from the familiar to the unfamiliar, has many traits with constructivism's emphasis on learner discovery, curiosity and open-ended learning. A fluid instead of a passive connection between instructor and learner occurs when learners are participating in their own learning (Hase & Kenyon 2013).

Self-regulated learning

Self-directed learning is a wider term that incorporates and comprises SRL, where the self-directed learner is expected to self-regulate; however, SRL does not encompass SDL completely (Loyens 2008; Saks 2014). According to Zimmerman and Schunk (2001):

> […] Learners are self-regulated to the extent that they are meta-cognitively, motivationally, and behaviourally active participants in their own learning process […] Learners check the success of their learning techniques or tactics and react to this 'feedback' in self-regulation learning. (p. 5)

When learning is self-regulated, the primary emphasis is on the learner's capacity to evaluate and adjust their learning strategy in response to their own personal learning needs.

Regarding education, Bandura et al. (2001) found that most of it is learnt via observation and comparing one's behaviour to established norms. A positive evaluation occurs if a person's behaviour meets or exceeds one's performance requirements; on the other hand, a negative evaluation occurs if it misses the mark of one's expectations. Perceived self-efficacy is similarly shaped by one's own successes and failures, both real and imagined, as cited in Hergenhan and Olson (2009). There are many similarities between an SRL and SDL programme. Self-directed learning contains aspects of a self-actualised learning programme. Unlike SRL, where teachers adopt a more active role, SDL does not rely heavily on modelling and external reinforcement, such as the teacher or other learners (Zimmerman & Schunk 2001).

Self-directed learning

The theory of SDL was made famous by Knowles (1975) and originated from the assumption that educational techniques for educating adults should be completely separate from that for adolescents. However, new research has shown that adolescents can become self-directed (Karatas & Arpaci 2021). Knowles' views are based on the idea that a person's level of maturity as a learner predicts how much they will take charge of their own education. Knowles (1975) characterises SDL as:

> [*A*] process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing learning strategies, and evaluating learning outcomes. (p. 18)

As a way to individualise and personalise what would otherwise be a standard educational system, Knowles (1975) promoted flexibility, choice and independence for learners and fostered various forms of learner assistance (tutoring, counselling and advice). For SDL to work, it must be assumed that intrinsic factors drive learners, for example, the drive for self-esteem (particularly in terms of self-worth), the desire to succeed, a sense of growth and fulfilment in one's own abilities, and a general curiosity in the world around them (Knowles 1975). In PoP, SDL is taken a step further, shifting learners from more controlled and less autonomous educational situations to more free and unstructured playful learning environments (Blaschke 2012; Garnett & O'Beirne 2013; Karatas & Arpaci 2021; Luckin 2010):

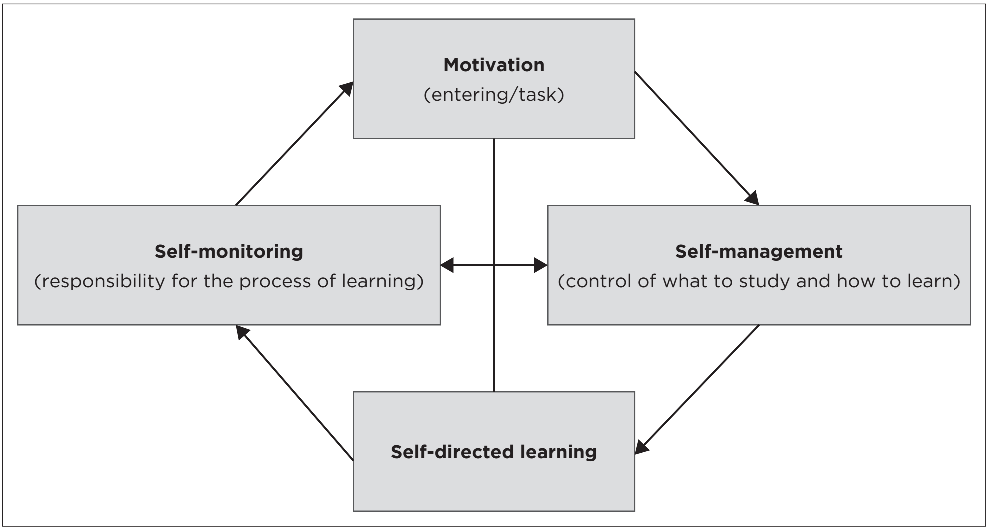
1. Therefore, firstly, in order to improve SDL, learning might be done in groups. Social, methodological, cognitive and practical components

are among the four definitions of SDL posed by Long and Associates (2000). The psychological component of SDL focuses on the internal processes that contribute to SDL, including the four supplemental elements of competence, choice, control, confidence, metacognition, motivation and self-regulation. The three defining features of a self-directed learner are 'independence', 'the capacity to make choices' and 'the skill to convey the norms and constraints of a learning activity' (Muongmee 2007). When defining SDL, Williamson (2007) agrees with Knowles and identifies the same five broad categories – the ability to recognise the conditions that foster initiative.
2. Secondly, methods of learning that may help one become more independent.
3. Thirdly, the learning tasks in which learners should participate actively to develop their own sense of autonomy in their studies.
4. Fourthly, using assessment to keep tabs on how much learners are learning.
5. Lastly, considering learners' social abilities.

All of the following, according to Williamson, are necessary before one may become self-directed in their pursuit of knowledge. According to Warburton and Volet (2012), self-directed learners can ask the right questions to steer their learning, as well as learners who can effectively communicate with their colleagues (Bary & Rees 2006; Williamson 2007). As Merriam and Caffarella (1991) note, self-directed learners commonly seek out individuals with similar learning requirements to explain and simplify issues and exchange ideas, information and resources. Okoro (2011) and Karatas and Arpaci (2021) emphasise the importance of progressive learner ownership of learning in SDL, which is accomplished via discourse and discussions that challenge learners to think critically and develop their capacity for greater levels of comprehension.

Contextual control, cognitive responsibility and motivation (entry and task) elements all play a role in learning, according to Garrison's SDL model (1997) (see Figure 2.2). Learning is a collaborative progression in which learners adopt accountability for and control over their own cognitive (self-monitoring) and environmental (self-management) processes in producing and verifying meaningful learning results. Taking a cognitive approach, Garrison sees SDL as a collaborative effort in which the learner assumes accountability for generating meaning while also involving the input of others in validating important information (social perspective).

As per Garrison (1997), an important part of effective self-management is managing learning objectives, resources and support. It is in the research on self-regulatory motivation that we find the term's essence (Pintrich & DeGroot 1990). The elements of competence, resources and dependency



Source: Garrison (1997).

FIGURE 2.2: Garrison's model of self-directed learning.

are used to establish task management (Garrison 1993). The facilitator's and the learner's talents and capabilities are measured by proficiency. Various supporting and assistance services are accessible to learners in an educational environment. A learner's integrity and freedom of choice are reflected in their interdependence on their institution or subject's standards and norms. The instructor and the learner work together to help the learner manage their own learning activities. In order to achieve excellent educational results, the teacher must maintain an adequate dynamic equilibrium of external control (Prawat 1992; Resnick 1991).

Self-monitoring is another SDL component proposed by Garrison (1997). Cognitive and metacognitive functions such as self-awareness and the capability of looking within and analysing one's own cognitive processes are all addressed in this chapter. In this process, the learner assumes responsibility for constructing their own meaning by integrating new concepts and ideas with their prior knowledge (Parkes 2021). Metacognitive perspectives on learning and the capacity to learn reflectively are supported by this method. Reflective learning may be helpful to 'create learners who can gauge themselves in a range of contexts' (Candy, Harri-Augstein & Thomas 1985). There is a lack of clarity and specificity in internal feedback; therefore, teachers can give useful feedback to assist learners in self-monitoring the quality of the learning output. The learner's competency (abilities and methods) and the contexts and epistemological expectations all have a role in how much self-monitoring they do throughout the learning process (Butler & Winne 1995; Garrison 1991).

Finally, motivation catalyses a person's desire to learn and attain their cognitive objectives. Entering and task motivation are two types of motivating factors (Zheng & Tan 2019). The act of expressing motivation signals a person's willingness to commit to a certain goal and take action. 'Commitment – the joining together of attitudes, sentiments and aims' is one possible interpretation (Halverson & Graham 2019; Thomson 1992). Task motivation refers to a person's ability to concentrate and persevere on a certain task or goal. According to Corno, 'motivational elements [...] affect intentions and drive task engagement' (1989, pp. 114–115). Valence and anticipation are thought to have a role in determining entry motivation. Valence is a measure of how much a person values a given educational objective. People's wants (or values) and emotional states shape the valence of a message (preferences). Expectancy is the notion that a desired goal may be accomplished in a learning situation (Pintrich & DeGroot 1990). Volition and task control are intertwined in the concept of task motivation. What we call 'volition' in a learning environment is 'the ability to align one's emotional and behavioural preferences to a certain objective' (Kanfer & Ackermann 1989). Volition is concerned with maintaining an intentionally high level of effort or diligent performance to influence perseverance and task performance (Pintrich & DeGroot 1990). Garrison's model of SDL is essential to any pedagogically playful activity. Towards the end of the chapter, this model will be incorporated into a new self-directed PoP framework.

Problem-based learning

Problem-based learning is a teaching method that focuses on developing learners' problem-solving abilities by allowing them to take control of their own education via an SDL approach, which also involves teamwork skills (Moust, Bouhuijs & Schmidt 2021). Learners are given inelegant, disorganised and ill-structured circumstances in which they assume the position of the situation's owner (see ch. 1). Problem-based learning has numerous benefits over conventional lecture-based instruction, including the fact that learners get to see the issue and the solution first-hand. Making learning relevant to reality, encouraging and pushing learners to study, and engaging learners in a way analogous to the real world are only a few benefits (Ali 2019). In addition to problem-solving, PBL promotes the growth of various other abilities and qualities. It has been argued by Larsson (2001), as well as Seibert (2021), that learners in PBL classes develop better social skills because they have more opportunities to practice using their preferred (or mother-tongue) language in real-world situations. Problem-based learning might be difficult to implement in a regular classroom environment if learners and teachers cannot grasp the concept of active or meaningful participation (Ali 2019). Learners who participate in PBL must have an SDL disposition and engage in active learning practices. It was a radical departure from standard methods of instruction and educational thinking (Seibert 2021).

Cooperative learning

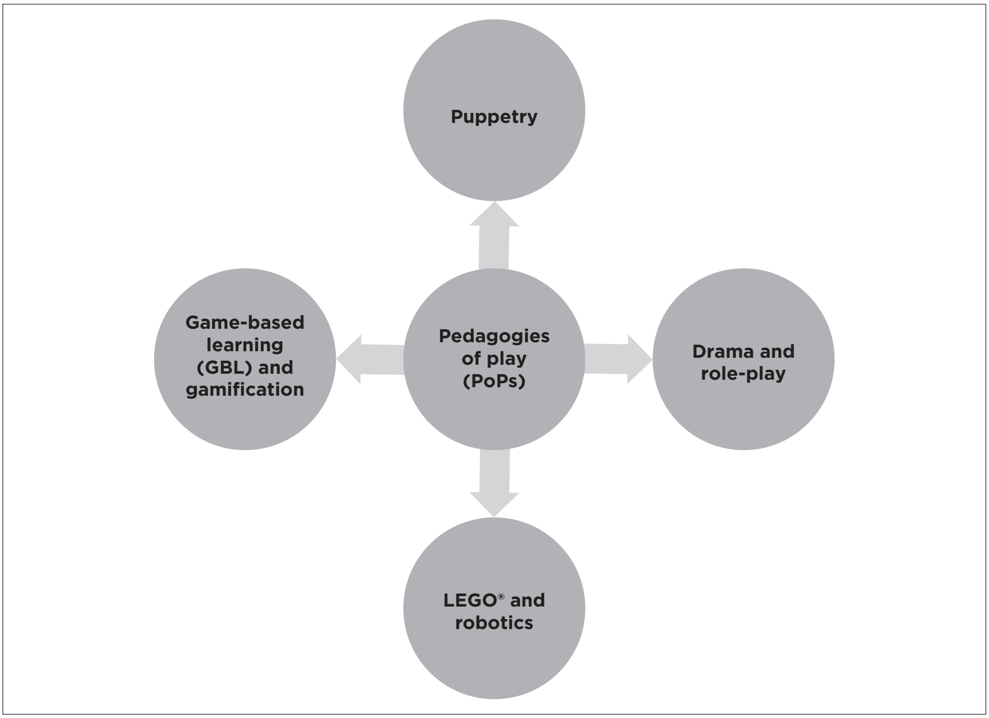
Small groups of learners collaborating with each other in teams to solve issues, complete specific activities and assignments, or attain shared learning objectives are referred to as CL by Johnson, Johnson and Holubec (2013). Using non-competitive interactions among small groups of learners, CL is a learner-centred method of active learning (Bores-García et al. 2021; Sandi-Urena, Cooper & Stevens 2012). As a result, CL gives learners back command of their own education. Johnson et al. (2013) identified any CL environment's five essential features:

1. **Positive interdependence:** Interdependence between group members is said to be positive if it fosters an awareness that no one can achieve personal success until the collective as a whole does (Turgut & Gülşen Turgut 2018).
2. **Individual accountability:** As a result of individual accountability, each group member must be actively engaged in achieving the group's goals and understand his or her role in the group's success (Mentz, Van der Walt & Goosen 2008).
3. **Collaborative skills:** When it comes to social and small-group abilities, everyone in the group must be able to utilise their communication and decision-making abilities and their capacity to develop trust, deal with conflict and lead the group to success (Tran 2019).
4. **Face-to-face promotive interaction:** If team members work carefully with each other, they can assist one another and exchange resources (Kövecses-Gősi 2018).
5. **Group processing:** The team would continually examine how they work as a group to enhance their collaboration (Johnson et al. 2013).

Not all PoPs will necessarily allow for the inclusion of CL. However, any kind of playful activity involving groups could be enhanced by including the five elements of CL. This could also potentially include PBL and PoP activities.

Pedagogy of play strategies

As mentioned in this chapter, several theories exist that can link to or encourage PoP. However, we now need to understand how PoP can be used in a practical sense. Therefore, this section will delineate the various strategies used within PoP. Several of these strategies are also used in the



Source: Author's own work.
Key: PoPs, pedagogies of play; GBL, game-based learning.
FIGURE 2.3: Pedagogies of play strategies.

proceeding chapters of this book. Figure 2.3 displays the various strategies that are linked to PoP.

Puppetry

In Kröger and Nupponen's (2019) opinion, puppets may be more widely used in classrooms as teaching aids. Puppetry is an early type of amusement used to convey concerns and opinions in diverse human communities; puppetry has a long history as a kind of tradition and culture (Brits et al. 2016). When the Latin term 'pupa' was translated into English, it referred to a little creature (Ahlcrona 2012). People have long been attracted by the concept that a puppet 'lives' and has inspired their imaginations. The actions that puppets participate in enable their communication potential to develop, enabling viewers' (learners') ideas, feelings and connections to be predicated on these activities, according to Ahlcrona (2012).

Other types of puppets, also including hand puppets, rod puppets and finger puppets, are also available for performers. The educational setting dictates the kind of puppet utilised, such as remedial, rehabilitative or regular teaching–learning purposes. Teachers often use puppets in a puppet theatre to demonstrate attitudes or other possible subjects, such as disability (Kröger & Nupponen 2019). This allows for additional depth to emerge. Composing a puppetry script, acting with the puppet and adding it to a topic may all be considered forms of creative instruction (Kröger & Nupponen 2019; Tzuriel & Remer 2018). Neurodiverse learners may also benefit from puppet-based instruction, as puppets promote concepts such as self-worth, emotional release and other difficulties (Purcell-Gates & Smith 2020). It is possible to use puppetry for an extended period of time because it appeals to a wide range of applications and themes, as per Gobec (2012).

The teacher, fulfilling the role of the puppeteer, might give a goal, and the students can discuss it while performing the puppet show (Ahlcrona 2012; Gobec 2012). When a student takes on the role of puppeteer and uses the puppet to participate in a dialogue with a teacher or peer to show knowledge, this is another kind of mediation. Mediated learning experiences, as described by Feuerstein et al. (2006), may be thought of as the normal way students engage in learning and are then managed by an agent (either the teacher as puppeteer or student as puppeteer – using the puppet) to achieve educational objectives or aims. Using more than ten studies, Kröger and Nupponen (2019) analysed the literature on puppets as an instructional tool and found five potential benefits of puppetry in the classroom, including:

- increasing communication
- improving classroom climate
- fostering creativity
- fostering an atmosphere that promotes teamwork and cohesiveness
- shaping the perspectives and actions of students.

The potential benefits are discussed in this section in more detail.

Improving communication output

Kröger and Nupponen (2019) state that two-way contact between students and teachers is possible. A student's ability for introspective thinking influences both their degree of comprehension of a subject and their success in fulfilling a set of learning objectives; therefore, metacognition and knowledge transfer go hand in hand. Puppets might act as a go-between for the teacher and student when it comes to teaching, talking and making human connections (Ahlcrona 2012; Keogh et al. 2008; Korošec 2012, 2013).

Fostering a positive classroom environment

There are three aspects to classroom atmosphere, all of which have been identified by Evans et al. (2009), namely academic, managerial and emotional. These three components may be improved by using puppets, increasing learner enthusiasm (Kröger & Nupponen 2019).

Creating a creative space

According to Brėdikytė (2002), puppetry may stimulate individual creativity because puppets challenge and allow learners to express themselves incorrectly. Because of this, learners are forced to come up with their own innovative solutions to problems they face when confronted with a puppet teacher (Ahlcrona 2012).

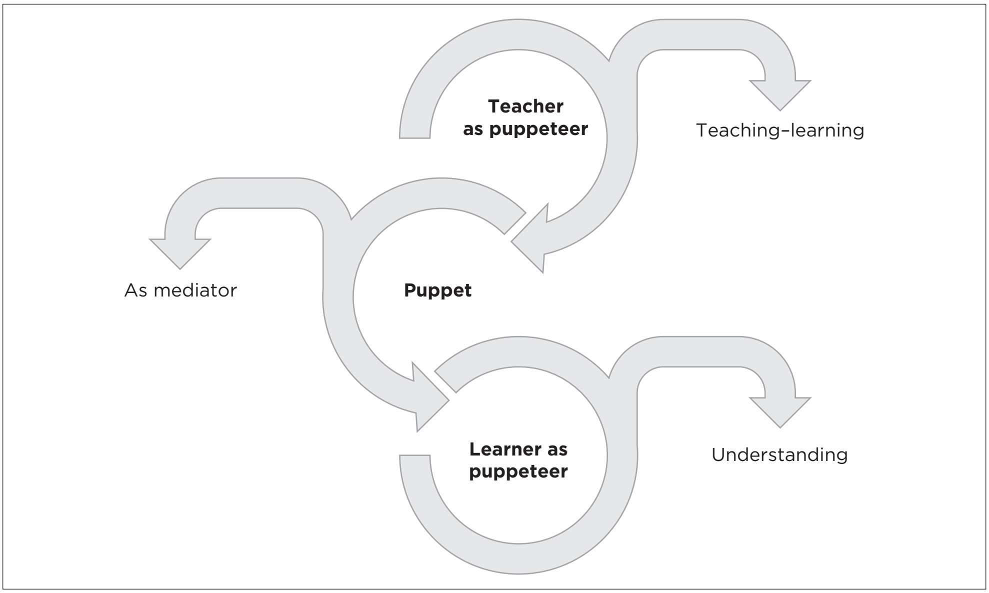
Fostering cooperation and group integration

By releasing stress when students are in a position to support the puppet and, while doing so, relieve themselves, puppets may help students integrate and participate in group work (Korošec 2012). Kröger and Nupponen (2019) and Remer and Tzuriel (2015) both find that using puppets in social settings has positive effects.

Influencing learner attitudes

Puppets appeal to learners of all ages. Whiteland (2016) finds that the use of puppets helps learners to develop new meanings about a subject. As a result of gaining a better grasp of the issue, individuals may have a more favourable outlook on it. As a study of available literature demonstrates, there is little research on how puppetry is used in schools (Keogh & Naylor 2009). In addition, teachers are wary about using puppetry as a means of teaching and learning, among other things (Brits et al. 2016). Figure 2.4 depicts how puppetry is used to mediate the learning process by teachers as puppeteers and, in certain situations, by learners as puppeteers.

In Figure 2.4, when teachers use puppets, learners sense comfort: They are freed of their anxiety around authority, connecting with their classroom context and what is actually explained (Korošec 2012). Learners frequently trust in the puppet, which they enjoy feeling and rubbing (sensory), resulting in comfortable subject dialogues that allow teachers to fulfil curriculum objectives in a good classroom setting (Korošec 2012). When learners utilise a puppet, they are more likely to express themselves because any mistakes are the fault of the 'puppet as a person' rather than the learner (Ahlcrona 2012). When discussing a certain subject and asking these questions to the puppet, the instructor may also uncover mistakes in the

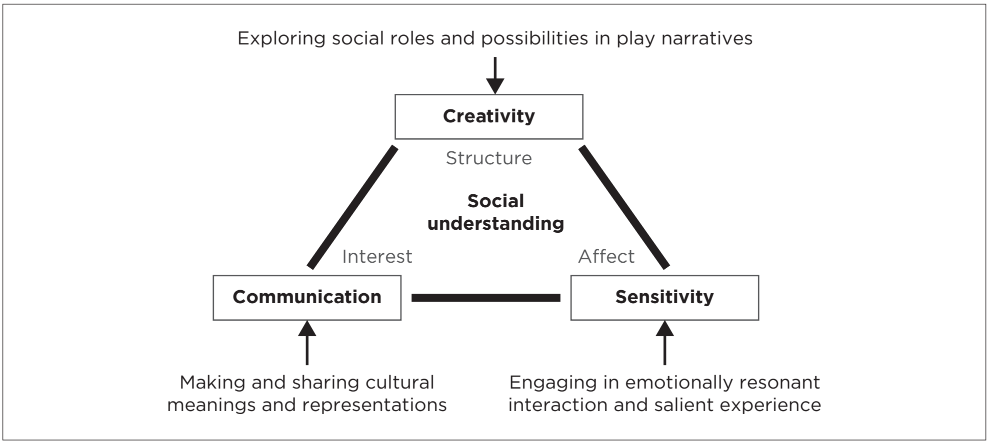


Source: Author's own work.
FIGURE 2.4: Puppetry as a mediator of learning.

learners' knowledge, enabling the learner to take notice of these inaccuracies and learn from them.

Drama and role-play

There are three elements that, when combined, make play tutoring and drama work a successful teaching and learning approach (Sherratt & Peter 2002). Learners' pleasant 'feel good' component from engaging with people and their rising self-awareness as they learn about cultural customs and acceptable reactions to those traditions must be capitalised on as a first step. Neuroscientific studies demonstrating the link between emotional engagement and improved cognitive performance lend credence to the effectiveness of theatre as a teaching method (Viirret 2018). Similar to daydreaming and other altered mental states, playful behaviour in learners may cause the release of neurochemicals and the opening of previously closed neural connections (Pitruzzella 2022; Sherratt & Peter 2002). Therefore, consistent exposure to drama may lead to the development of more flexible thought patterns in the brain. Mirror neurons, which are recognised to be asymmetrical in autism, will likewise be stimulated by dramatic involvement (Ramachandran & Lindsey 2006). After experiencing something, our 'gut reaction' is aroused, which prompts us to rationalise our emotional response and put it into an



Source: Pitruzzella (2022).
FIGURE 2.5: Drama characteristics in a learning environment.

acceptable narrative course (Zeng 2019). As a result, learners would have a more cohesive and relevant educational experience if the environment included components that were meaningful to them personally (such as a favourite toy or colour, which might be included in props or costumes).

Other significant dynamics, both of which are tied in particular to the instructor roles, were also highlighted by Kaiafa, Dima and Tsiaras (2020). For starters, creating an energising and enticing shared learning environment is essential – the emotive involvement is seen to be genuine in a setting that is perceived to be authentic while being fictional. It is also important to create conflict between the protagonist's original point of view and a counter-position (typically offered by the instructor in character) that keeps the story moving. As with caregivers in early play interactions who inject melodrama, humour, suspense, warmth and excitement into activities, teachers have an emotional significance for attracting learners (Dimnjašević 2020). Emotionally enhanced interactions promote direct knowledge of another's mental state and a 'theory of mind', which is the basis for invoking intuitive reactions (Peter 2021). Social imagination, the capacity to take on board a depiction of another person's mental processes without necessarily sharing them, has profound consequences for this development (Zeng 2019). These characteristics are presented in Figure 2.5.

Interest

For learners to benefit from the drama sessions, they must be taught at a level suitable for their cognitive abilities, and the subject must be relevant. Real, meaningful things from their everyday lives must be adapted to their ordinary usage (such as a mug, a fork or a toothbrush) (Pitruzzella 2022). Additionally, a drama lesson must aid the learners' growth in their representational knowledge by having them work diligently to modify the classroom setting to generate a make-believe world and imaginary characters (assisting teachers in character with items of clothing) (Kaiafa et al. 2020). Learners and learners may then be introduced to a different metaphorical departure: Familiar items (like a table) can be utilised as props and can gain new meanings (like beds) with the aid of blankets and pillows. An important aspect of the group experience is that new meanings may be generated. These nonlinear relationships can be expressed with others, leading to greater interest and motivation. This directly correlates with SDL, as motivation has previously been discussed as one of the pillars of SDL, as outlined by Garrison's (1997) model.

Affect

Educators require emotional intensity and immediacy to stimulate awareness of an 'other in the meeting of minds' (Pitruzzella 2022), which is the basis for a feeling of 'relatedness' and an early theory of mind (Kaiafa et al. 2020). Educators must give a sense of security by absorbing and reacting to various learners' emotions. Learners benefit from the attitude and dedication of their educators as it triggers their emotional mechanisms that otherwise would be impotent or dormant. Caregivers instinctively exaggerate their answers to increase the significance for newborn infants. Their concentration must be captivated by the conversation and not diverted by the surrounding environment. However, the employment of aesthetically appealing costume elements may make apparent the 'another's' pretence and awareness, but they must not be so ornate as to detract from the role's main connotations (Dima & Tsiaras 2021).

Structure

Learners may learn to recognise and anticipate in a theatre lesson. By altering the obstacles for individuals within the well-known storyline, the drama lesson may be an important tool for extending the learners' play (for instance, the variety of hygiene products available for selection and the level of supervision provided by adults). This might lead the group's story in an unexpected direction, or it could be 'tweaked' revealing a previously hidden plot twist (Peter 2021).

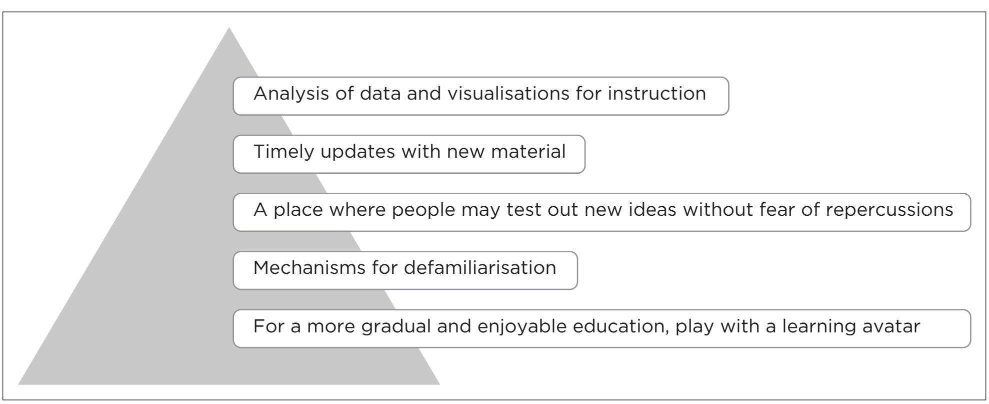
Game-based learning and gamification

Firstly, learner self-efficacy, learner self-determination, motivation, curiosity, intention, ability, goal and task alignment, self-awareness, reflection and other conceptions of SRL are all discussed in-depth in Zap and Code's (2009) study of SDL in gaming settings. Features of gaming settings that facilitated SDL were investigated, such as an authentic learning environment, allowing students to practise making choices in a safe, simulated setting. Secondly, students apply what they have learnt in a realistic yet simulated environment. Thirdly, GBL allows students to learn via observation and imitation. Fourthly, students have taken on a wide range of roles in the process of discovering and creating new ideas. In the end, there are places where people may work together under the guidance of (virtual) mentors to acquire new skills and expand existing ones. Independent learning techniques from video games were the focus of another research that deviated from the theoretical paradigm utilised. Interviews and the think-aloud technique were also utilised to uncover what aspects of game design contribute most to the success of SDL in gaming contexts.

Game-based learning factors promoting self-directed learning

This section provides some significant variables that game designers and educators might consider while building games to encourage SDL in video games in instructional settings based on the research of the user's context (Toh 2018) (see Figure 2.6). These factors comprise affording 'learning analytics as a metacognitive tool', 'gradual release of new information over time', 'a safe space', 'defamiliarisation mechanics' and 'scaffolded learning'.

Figure 2.6 outlines a self-directed PoP framework developed by the author.



Source: Toh and Kirschner (2020).

FIGURE 2.6: A synopsis of the elements that foster self-directed learning.

☐ Learning analytics as a metacognitive tool

Learning analytics may promote SDL and education for the 21st century by enabling learners to monitor their behaviour, decisions and performance by visualising trends and offering quick feedback via computer or mobile platforms (Aldowah, Al-Samarraie & Fauzy 2019). However, this is not always the case when the learning analytics data are presented to users and mostly operated at the back end. Including learner analysis and data visualisation in a game or class environment can help learners evaluate their gameplay activities or the learning procedure and enable learners to evaluate their performances and learning compared with other learners' baselines.

☐ Gradual release of new information over time

New knowledge may be developed in educational games and delivered progressively, 'just-in-time', to enhance SDL (Gee 2005) as a learner progresses throughout the game or classes. Most games merely offer players a lesson in fundamental movement and environmental interaction. Only after the prologue or introduction of the game was more sophisticated information provided, such as how to progress.

☐ A place where people may test out new ideas without fear of repercussions

Research on GBL suggests that students may be more willing to experiment with new methods of approaching a problem or a challenging topic without worrying about how their efforts will be evaluated. This is paramount for their future success in the real world (Toh 2018). Low-stakes assessments that do not count toward the final grade, prerequisites grading and assessment for learning are all examples of methods that may be used to do a formative evaluation of student progress (Heritage 2018). The data gathered from educational video games might be used as a type of formative (formal) assessment by teachers.

☐ Defamiliarisation mechanics

Self-directed learning approaches, for example, reflection and improvisation, may flourish when students see a situation as fresh and, therefore, more likely to react creatively (Watkins & Marsick 1992). Defamiliarisation mechanics are a kind of design and implementation in video or tactile games that are used for instructional reasons by making some game mechanisms nonroutine compared to those employed in the game's beginning (Mitchell 2018). Because of this, defamiliarisation mechanisms may be employed to encourage learners to create metacognitive techniques for learning how to forget and relearn. Rather than teaching students model solutions that they are unlikely to utilise in the real world, research suggests that instructors might adopt different approaches to defamiliarise learners, such as having learners solve problems in multiple situations, to increase their learning. In GBL, tasks can be tailored to the learner's ZPD throughout gameplay (Verma et al. 2019), and stealth assessment can be used so that testing is practically undetectable (Verma et al. 2019).

Scaffolded learning: An in-game companion

Scaffolded education is beneficial because it helps students progress and allows for material mastery. By building on the learner's existing understanding, scaffolding puts into reality Vygotsky's (1987) concept of performing tasks in the ZPD (Wells 1999). Educational scaffolding is based on three pillars. To begin, co-constructing information in a conversational setting is essential for understanding speech. Secondly, it is crucial to consider the nature of the behaviour in which knowledge (creation) becomes ingrained. Finally, artefacts play a critical function in creating original knowledge (Wells 1999). Educational game designers may begin implementing and incorporating a companion or in-game humanoid character to motivate the learner's (scaffolded) SDL in digital, computer-media contexts in light of the foregoing assumptions and previous studies examining the role of a learning companion in increasing social relationships with learners and motivating learning (Michaelis & Mutlu 2018). Users might gain experience making difficult moral decisions with the help of an in-game aide.

LEGO®

The toy company LEGO® was started in 1932 by Ole Kirk Kristiansen as *leg godt*, who defined it as 'play well', and subsequently, the LEGO® Group has prospered as a family-owned business. After its introduction in 1958, LEGO®'s brick-shaped toy blocks went on to inspire a broad range of themed sets and play options (Mortensen 2012).

By adhering to the highest levels of testing, the LEGO® Group ensures that its products meet the highest quality standards and demonstrate the greatest level of responsibility to its stakeholders by promoting an environment that fosters creativity and innovation (Jensen, Seager & Cook-Davis 2018). Random testing throughout the manufacturing process and customer input are all approaches through which quality assurance is carried out in research and development (R&D) (Zosh et al. 2017).

The corporate responsibility standards (CRS) of the LEGO® Group reflect deeply ingrained ethical beliefs in the company's corporate structure (LEGO® Group Progress Report 2012). For instance, LEGO® Six BRICKS educational initiative may be used with sets from any period or set type, and they can be used to build anything, making them suitable for the company's concept of 'sustainable play' (LEGO® Group Progress Report 2012):

> I think that by putting our goods in the hands of youngsters, we may have a tremendous effect on the future [...] The physical interaction with our toys encourages [*their*] imagination, creativity, and learning, and aids in their development as tomorrow's builders. Our activities must be safe for our workers and partners, as well as as clean and gratifying for the local communities [*that we serve*]. (p. 23)

Avcı and Şahin (2019), Çankaya, Durak and Yünkül (2017), and Kalelioğlu (2017) all present strong evidence that educational gaming applications built with LEGO® Duplo® bricks increase students' problem-solving and reflective-thinking abilities (2015). To provide one example, Kalelioğlu (2015) conducted an experiment with elementary school students using the Code.org coding platform and found that their ability to think critically and solve problems improved. An increase in efficiency and improvement in creative problem-solving abilities were discovered by Çankaya, Durak and Yünkül (2017) in Grades 6 and 7 learners who received robotics-based coding instruction.

Educational robotics

Robots' capacity to aid in children's education is now widely acknowledged, and their use in educational settings is rising. They support technical courses like programming and non-technical ones such as science, technology, engineering and mathematics (STEM) (Zhong et al. 2022). They may even be used to aid in telling stories (Stork 2020) and other creative endeavours.

In recent decades, much study has focused on the importance of experience as an integral component of learning (Morris 2020). This success with robots in education is a direct outcome of that work. According to Piaget (2003) and situated cognition academics, 'to know is to relate', and 'knowledge is not a commodity to be communicated'. Instead of being taught, children 'actively develop their own mental framework', which they do through gaining experience and interacting with objects. As a result, the learning process was transformed by the act of programming. Rather than imposing information on them, this exercise encourages learners to take a more active and self-directed role in learning.

As part of these research studies, play and artefacts were also pushed to the forefront of the discussion on education as a fundamental facet of human learning. Playing is an excellent way for youngsters to develop habits that will help them grow intellectually. In the process of assimilation, which Piaget refers to as play's unique purpose, toddlers learn to interact with new objects and circumstances by remembering previously learnt schemas, or building blocks, of intelligent behaviour (Morris 2020). There are several ways in which the individual's ability to gain knowledge may be expanded, including toys, everyday items and the surrounding environment. A pendulum, for example, may become an 'object-to-think-with' via play, regardless of whether it is a computer or a robot (Morris 2020).

The LEGO® MINDSTORMS® EV3 Home application, designed by the Massachusetts Institute of Technology's (MIT) Media Lab and licensed by the LEGO® Group, is the most widely used example of robotics used for educational purposes (Afari & Khine 2017). The MINDSTORMS® Robotic Invention System was introduced by LEGO® in 1998 and consisted of programmable bricks, sensors, actuators and LEGO® Technic parts. The MIT Media Lab projects and research in the 1990s led to this product, including the annual LEGO® Robot Design Competition and the Programmable Brick project in particular (Johal 2020). The LEGO® MINDSTORMS® EV3 Home application is now widely available and being utilised in various scenarios, with an increasing number of educators turning to it for hands-on learning activities. Thymio (Mondada et al. 2017) and Cubetto (Anzoategui, Pereira & Jarrín 2017) are only two of the many computational thinking–teaching robots now on the market.

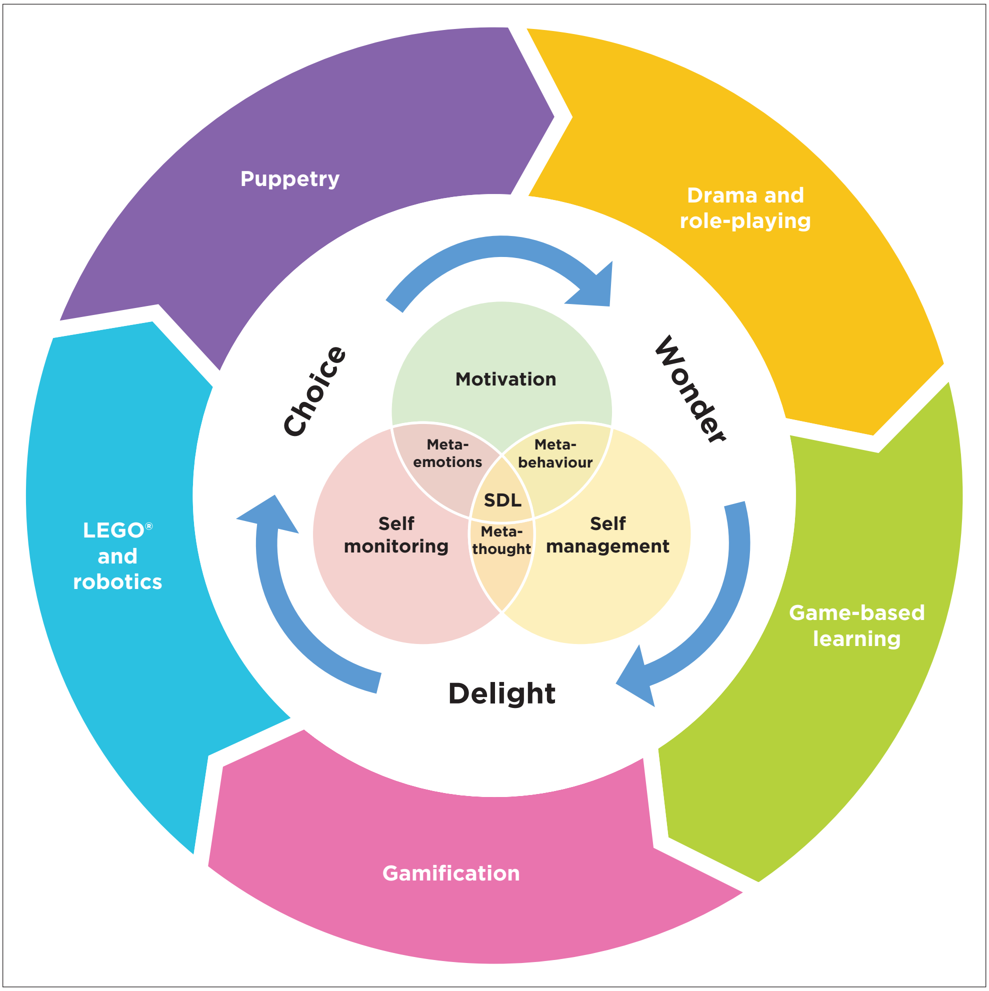
Playful learning using robots built to display social behaviours, rather than assembly kits, was investigated in less systematic and long-term experiments. It is common for educational programmes to use social robots in the form of teachers or caregivers (Papadopoulos, Sgorbissa & Koulouglioti 2018). But some studies have shown that children's interest and learning may be improved by having a robot as a friend. When Tanaka and Matsuzoe (2012) introduced the notion of the care-receiving robot, they demonstrated how children might improve their learning outcomes by instructing the robot. Short et al. (2014) also make the case for youngsters serving as teachers. Using *DragonBot* (also developed by MIT), the authors demonstrate how to use a practical toolbox for creating social robots. Rather, in other research, the robot was used as a mediator. Children with learning impediments can now play in a variety of ways thanks to a robot companion built by Marti and Iacono (2011). Rather, Kronreif et al. (2005) developed a Cartesian coordinate robot which allows learners with significant body limitations to engage with common toys, such as blocks or bricks.

According to Ortiz-Colon and Romo (2016) and McGill (2012), learners' attitudes are favourably influenced by robotic applications. LEGO® MINDSTORMS® robotics education kit garnered learners' attention and boosted their enthusiasm for related reading (McGill 2012). Furthermore, according to Ortiz-Colon and Romo (2016), LEGO®-based applications boost learner interest in academics. It was found that learners actively engaged in robot-related activities and that these activities effectively encouraged them. According to research, learners were shown to be more engaged and motivated while participating in robotics activities (Alimisis 2013). Motivation for the session may positively impact learners' ability to learn to code. Learners' future professional growth may be aided by robotics-based apps, which pique their interest and keep them engaged. According to other findings, the academic motivation of kids in the *Scratch* group did not grow more than that of learners in the LEGO® group. For research applications in general, the attitude and desire of learners to participate may significantly impact outcomes. Learners' academic motivations might also be affected by the length of the processes and the number of applications (McGill 2012). Conversely, learners' desire to do well in class may be diminished if they are not given credit for their efforts. Study after study shows a correlation between academic desire and a learner's success score (Broussard & Garrison 2004; Pelch 2018).

Figure 2.7 outlines a self-directed PoP framework developed by the author. In it, the outer circle has five different PoPs that encircle the rest of the framework. These actual pedagogies comprise puppetry or avatars, drama and role-playing, GBL, gamification, LEGO® and robotics. Each of these pedagogies must incorporate the three characteristics of playful learning: choice, wonder and delight. If either of these elements is missing, then the activity cannot be considered a PoP. Within the inner part of the framework lies the core SDL component, which is adapted from Garrison's (1997) model.

Instead of separating the three elements of motivation, self-management and self-monitoring, the three SDL components overlap in a PoP framework, as seen in the Venn diagram at the framework's core. Where these intersections occur, certain meta-characteristics can be observed and measured. For example, between motivation and self-management, meta-behaviours such as *trial and error*, *observation and modelling*, and *reinforcement learning* can be observed (Williamson 2015). The motivation level, which closely links to the playful characteristics, will ensure that learners are motivated enough to want to take part in the activity in the first place. Motivation will be assured if the learners are given autonomy and the activity allows for curiosity and enjoyment (Knittle et al. 2020).

In terms of self-management, the PoP will need to allow learners to exhibit some form of behavioural management and self-control. Learners could be expected to compete with one another or work in groups, which could lead to clashing ideas or personalities (Hagger et al. 2019). The meta-behaviours discussed prior could also assist in seeing how far learners are



Source: Author's own work.

FIGURE 2.7: A self-directed learning framework to foster pedagogy of play.

regulating their control over their learning. Between self-management and self-monitoring, certain metacognitive functions can be observed and measured. These include *connected learning* (Quigley et al. 2020), *reflecting and improvising* (Chang 2019), *logical and analytical reasoning* (Cullen et al. 2018), *inquiry-based learning* (Khalaf et al. 2018) and *synthesis* (Saido et al. 2018). These fall on a spectrum, similar to Bloom's taxonomy (see Ruhl, Hughes & Schloss 1987). Some exemplify lower-order thinking skills (LoTS), while others are higher-order thinking skills (HoTS). Whether the PoP is structured in a self-directed manner will ultimately dictate at what level these metacognitive functions will emanate.

In terms of self-monitoring, the learners engaged in the PoP must monitor their active participation and behaviour. This could result in learners getting too excited, for instance, where they will need to regulate their behaviour. Another example would be when a learner loses in a competition and has to subsequently monitor their emotions and motivation level to not distance themselves in terms of participation (Rivera-Pérez et al. 2021). Between self-monitoring and motivation, several meta-emotions could be observed and measured. The emotions of learners will ultimately dictate how motivated they are. It is incorrect to assume that a PoP will always lead to motivated learners (Kaimara & Deliyannis 2019). Depending on how the activities are structured, certain instances can lead to negative emotional states that could dampen the spirits of learners. Some of these meta-emotions include dissatisfaction, anger, curiosity and satisfaction (Rao & Gibson 2019).

■ Conclusion

This chapter aimed to outline the theoretical foundation of PoP and several PoP strategies that could contribute to the development of SDL. Therefore, a newly proposed framework for self-directed PoP balances the requirement for playfulness and self-direction. Future research will either reinforce or refute the conceptual links made in this proposed model. Potential novel findings may emerge that could change this model. Each is equally important, and each could be measured. If one aspect, such as the playful element, is favoured, it may throw out the balance entirely, sacrificing the self-directed element or vice versa. Therefore, it is important to consider each aspect carefully to maintain the balance.

Chapter 3

Designing interactive pedagogies of play through metaliteracy

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Abstract

This chapter explores interactive pedagogies of play (PoPs) through the theory and practice of metaliteracy. As a holistic pedagogical framework for developing reflective and self-directed learners in collaborative social environments, metaliteracy supports individuals to become active knowledge producers. The structure of the metaliteracy model includes interrelated roles, domains and characteristics that reinforce the scaffolding of play- and

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problem-based learning in multimodal contexts. The core components of metaliteracy are applied in practice through a set of flexible and adaptable goals and learning objectives. Through this analysis of metaliteracy concerning PoPs, we will describe interactive meaning-making in pedagogical situations involving collaborative problem-based learning (PBL) in four courses at both foundational and advanced levels of the college experience.

Introduction

This chapter explores connections between PoPs and the metaliteracy framework. Metaliteracy emphasises the reflective and self-directed individual through four learning domains, multiple learner roles and characteristics and adaptable goals and learning objectives (Mackey & Jacobson 2022). These core components of metaliteracy offer opportunities to highlight problem-based PoPs as mechanisms of self-directed learning (SDL) and the impetus for collaborative engagement in dynamic and multimodal learning communities. For instance, this approach involves the affective learning domain and asks students to reflect upon their emotions to understand why cognitive learning occurred. As a holistic model, the interplay amongst the different components is ongoing and iterative.

Similarly, play-based learning and PBL opportunities emphasise the interrelated metaliterate learner roles and characteristics. The teacher role supports multiple characteristics: being informed, open, collaborative and civic-minded. The importance of the learner as a producer in metaliteracy provides ample scope to integrate learning opportunities based on real-world situations and play-based scenarios that help students develop growth and SDL strategies.

Metaliteracy is reinforced in practice through four primary goals that include:

1. actively evaluating content while also evaluating one's own biases
2. engaging with all intellectual property (IP) ethically and responsibly
3. producing and sharing information in collaborative and participatory environments
4. developing learning strategies to meet lifelong personal and professional goals (Jacobson et al. 2018).

In addition, these primary goals are supported by a set of related learning objectives. This chapter will explore the last two goals related to creating and sharing information and developing individual strategies for lifelong learning through metaliteracy. This analysis sets the stage for future research to examine the application of additional metaliteracy goals and learning objectives in play-based learning environments. For instance, the process of meaning-making that emerges through PoP necessitates further study into the evaluation of content and ethical engagement with IP reinforced in the first two goals.

Following the conceptual exploration of the relationships among PoP, SDL, PBL, multimodality and metaliteracy, we examine *multimodal* PoP where these connections are evident: A locked-box challenge, collaborative digital whiteboard creation, digital storytelling production and digital media creation in the digital arts. These examples are adaptable to multiple disciplinary settings and varying student levels. Metaliteracy provides a framework for situating educational play through PBL activities that enhance SDL and PoP.

Creative pedagogy of play

Nilsson explores the concept of 'creative pedagogy of play' by analysing the work of Swedish scholar Gunilla Lindqvist who was influenced by Lev Vygotsky's theories of play (2009, pp. 14–22). According to Nilsson (2009, p. 14), 'creative pedagogy of play is an educational approach, which advocates the joint participation of children and adults in a collectively created and shared world of fiction – a playworld'. In this context, the playworld is collaboratively designed among the adult and child participants as an imaginative and creative activity to make meaning (Nilsson 2009, p. 16). Nilsson (2009, p. 17) argues that Lindqvist builds on Vygotsky's approach to play by exploring it as a 'comprehensive cultural theory of play' through the arts based on social interactions among adults and children to create meaning. Nilsson (2009, p. 16) emphasises the association between thought and action by suggesting that 'play creates a fictitious situation in which actions are carried out'. From Nilsson's perspective, play is an imaginative activity for meaning-making (Nilsson 2009).

Lindqvist's analysis of play through dance education focuses on developing meaning through dialogue and imagination (2001, pp. 41–52). She argues that 'play is imagination in action', which defines a critical relationship between one's creative thinking and behaviour (Lindqvist 2001, p. 50). According to Lindqvist (2001):

> Play creates meaning. The significance of play lies in its meaning, which reflects reality at a deeper level, and should not be interpreted as a realistic presentation of a certain action. Since the child has the capacity to create an imaginary or fictitious situation, this also favours abstract thinking. (p. 50)

From Lindqvist's point of view, the terms 'aesthetics and rationality, imagination and reality' are not opposing concepts but rather linked together in meaning (Lindqvist 2001, p. 50). In addition, 'physical action and emotional reaction co-operate' because 'emotion and bodily expression are connected' (Lindqvist 2001, p. 46). Play supports higher-level abstract thought processes through the interplay of imagination and creativity (Lindqvist 2001, p. 50). Lindqvist (2001, p. 50) observes that in dance, 'thought and imagination come into being through the expressive acts of the body in play', which she sees as a process of simultaneous activities that include thought, imagination and action. This holistic approach to play inspires Nilsson's assertion that Lindqvist (2009, p. 21) is seeking 'a connection between play and culture where artistic forms such as movement, sound, and drama are natural and original components'. Considering the wide range of elements described, the pedagogical application of PoP and playworlds offers the potential for developing higher-level abstract thinking through the arts, from dance and drama to fiction and digital media.

The foundation for Lindqvist 2001's interpretation of play as a form of meaning-making is grounded in the work of Vygotsky, who argues that play is essential to learning because it 'contains all developmental tendencies in a condensed form and is itself a major source of development' (Vygotsky & Cole 1978, p. 102). Vygotsky relates this definition of play to one of his pivotal theories, the 'zone of proximal development' (ZPD), which he describes as (Vygotsky & Cole 1978):

> [...] the distance between the actual development level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers. (p. 86)

This concept forms the basis of the scaffolding of learning through dialogue with teachers and peers who support self-directed learners in meeting their learning goals and objectives. Wood, Bruner and Ross (1976, p. 90) argue for *scaffolding* as a social process 'that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts'. In the same way that Vygotsky's ZPD goes beyond individual experience, scaffolding reinforces the ability of learners to solve problems in partnership with peers and instructors (Vygotsky & Cole 1978; Wood et al. 1976).

Vygotsky and Cole (1978, p. 103) connects play to higher-level thinking and learning 'from the point of view of development, creating an imaginary situation can be regarded as a means of developing abstract thought'. Vygotsky describes play within a more extensive internal and external process because 'superficially, play bears little resemblance to the complex, mediated form of thought and volition it leads to' and 'only a profound internal analysis makes it possible to determine its course of change and its role in development' (Vygotsky & Cole 1978, p. 104). This assertion suggests that meaning-making through play is informed by more than constructing imaginary scenarios or worlds because it also requires internalised reflection upon thoughts or actions. It is consistent with Nilsson's (2009, p. 42) interpretation that 'play is a dynamic meeting between the child's internal activity (emotions and thoughts) and its external activity'.

Malcolm Knowles (1975) defines the self-directed learner as someone responsible for all aspects of their learning, including:

> [...] diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. (p. 18)

Knowles (1975, p. 18) argues that this all-encompassing process takes place when 'individuals take the initiative, with or without the help of others', reinforcing both individualised and collaborative learning with peers or teachers. Similar to Vygotsky's ZPD and the related scaffolding process, SDL benefits from opportunities to engage with others in social settings (Vygotsky & Cole 1978; Wood et al. 1976). Garrison (1997, p. 21) argues for a comprehensive model for SDL that involves 'self-management (task control), self-monitoring (cognitive responsibility), and motivation (entering and task)'. While Garrison's (1997, p. 23) approach focuses on these interrelated components of the individual learner, he also argues for 'a collaborative constructivist view of learning' because 'the individual does not construct meaning in isolation from the shared world'. Garrison (1997) describes the relevance of this insight for educators when designing learning opportunities:

> Meaningful learning outcomes would be very difficult to achieve if students were not self-directed in their learning. Taking responsibility to construct personal meaning is the essence of self-directed learning. At the same time, taking responsibility for one's own learning does not mean making decisions in isolation. The challenge for teachers is to create the educational conditions that will facilitate self-direction. (p. 30)

Through this approach, educators must consider ways to foster self-direction in collaborative environments for learners to engage with peers and instructors. As part of this process, PBL development reinforces active participation in social contexts.

■ Problem-based learning

As part of his critique of the *banking model of education*, Paulo Freire (2000) argues for an active 'problem-posing education' that is facilitated in dialogue with students, as he states:

> [/]n problem-posing education people develop their power to perceive critically the way they exist in the world with which and in which they find themselves; they come to see the world not as a static reality, but as a reality in process, in transformation. (p. 83)

Through this transformative approach to education, learners engage with the world and each other to make meaning and create knowledge together. Rather than a passive method of rote memorisation, for instance, individuals are *liberated* to be active and collaborative in dialogue with teachers and peers because 'Liberating education consists in acts of cognition, not transferrals of information' (Freire 2000, p. 79).

In her definition of PBL, Diana Stentoft (2017, p. 55) draws upon the work of Freire and asserts that 'central to PBL is a break from students as passive recipients of knowledge supplied by the expert teacher'. Similar to Freire's concept of *problem-posing education*, Stentoft (2017, p. 55) argues that 'students learn through their active engagement with meaningful activities drawing on their own prior experiences, and thus, they create their own learning processes'. Stentoft (2017, pp. 54–55) summarises several key components that define PBL, including *active*, *student-centred* and *self-directed* learning that applies *constructivist principles* in support of *critical thinking* to solve *complex real-life problems*. As with SDL and problem-posing education, PBL is an individual and collaborative process built on group work and *communication competencies* (Stentoft 2017, p. 55). Problem-based learning involves interrelated dimensions of learning because it 'assists learners in their development of cognitive as well as metacognitive skills through emphasis on not only the academic product but also the academic (learning) process' (Stentoft 2017, p. 55).

Multimodality

Similar to how PoP is defined as a process of constructing meaning, the concept of multimodality is also linked to meaning-making. Kress (2010, p. 27) says that multimodality is 'a social semiotic theory of communication' that involves a process of *production* and *participation* in which 'knowledge is always produced rather than acquired'. The author (Kress 2011, p. 242) describes an interdisciplinary approach to multimodality that combines ethnography and social semiotics because it 'names a field of work, a domain for enquiry, a description of the space and the resources which enter into meaning, in some way or another'. Kress (2011, p. 255) says that 'multimodality includes all modes as socially shaped resources for making meaning: Action, movement; three-dimensional objects, such as instruments, tools, sculptures; space, socially shaped'. Olivier (ed. 2020) introduces 'self-directed multimodal learning' as:

> [*A*]n approach to education where individual modal preferences, communication through different modalities, as well as the blending of learning, teaching and delivery by means of different modes are employed with the aim of fostering self-directedness among students (p. xxxiv)

In support of this methodology, Olivier (ed. 2020, p. 4) argues that 'self-directed multimodal learning is informed by social semiotic theory as the foundational framework' and that, ultimately, 'multimodal learning is about making meaning'. From Olivier's (ed. 2020, p. 9) perspective, self-directed multimodal learning is transformative and facilitated through open education while being an objective for learners to strive towards. He (ed. Olivier 2020, p. 9) says that 'SDL is regarded as both a process and a learning aim, and multimodality is the vehicle and environment'. Ultimately, Olivier (ed. 2020, p. 15) presents a visual model for the four main 'levels of multimodality within multimodal learning' that encompass *individual*, *interactional*, *instructional* and *institutional multimodality*. He investigates each of these levels as separate components that are also interrelated within this comprehensive model of multimodality (ed. Olivier 2020, pp. 15–31).

The concept of multimodality is relevant to exploring PoPs because it involves meaning-making and SDL. In addition, the literature about PoP identifies a wide range of meaning-making modes that impact the learning experience and support learners as knowledge producers. For instance, as we have seen, Lindqvist (2001, p. 43) emphasises the importance of meaning in her analysis of play and dance by arguing that 'world, action and characters are interconnected in play, and the children create meaning, which provides a base both for abstract thinking and artistic, creative ability'. This relationship between play and the construction of meaning is grounded in the work of Vygotsky (1978, p. 104), who says that 'it is the essence of play that a new relation is created between the field of meaning and the visual field – that is, between situations in thought and real situations'. Lindqvist's work is focused primarily on the application of play in the world of the arts, which offers the potential for many different modes. The development of meaning in these contexts involves the interplay of imagination and real-world scenarios in multiple modalities.

The PoP literature includes further examples of research related to different modes of play that are wide-ranging and include such approaches as the use of *play-based card and board games* to teach early mathematical concepts in kindergarten or pre-primary school (early childhood education [ECE]) (Vogt et al. 2018). In this study, the researchers conclude that 'the educators were more enthusiastic about a play-based approach' and that 'their positive attitude might have been a contributing factor to the learning success of the children found in this study' (Vogt et al. 2018, p. 599). Another example of PBL includes implementing 'a Conceptual PlayWorld where children and educator collectively dramatised the concept of growth and the butterflies' lifecycle' (Li 2022, p. 285). Li (2022,

p. 290) argues that through this interactive modality involving both verbal and nonverbal communication, 'the key to developing powerful collective play environments to strengthen children's conceptual thinking is the educators' affective engagement in this important process'.

The literature also investigates challenges related to integrating digital technology into PoPs activities. Edwards (2013, p. 208) argues that while 'play might well be understood as how children make meaning and learn about their worlds', it is often separated from the PoP in early childhood education (ECE). Edwards (2013, p. 208) argues for a 'consumption-as-social-participation' approach 'to highlight the extent to which the evolving nature of the cultural context creates conditions that manifest the need for potentially different iterations of what might be considered 'play'. In this reimagined context, 'online virtual play with avatars becomes a necessary support to early digital literacy' (Edwards 2013, p. 208). In another example, Palaiologou (2016) conducted a study among teachers in five different countries to investigate why teachers are reluctant to incorporate digital technologies in play-based pedagogy. This finding indicates that while the teachers surveyed are comfortable using digital devices in their everyday lives, they do not apply it in their pedagogy related to play-based activities (Palaiologou 2016). The author concluded that 'three key dispositions can be identified – functional, emotional and cognitive – that might hinder the integration of digital devices' into their instructional practices (Palaiologou 2016, p. 316).

Through this exploration of PoPs, meaning-making emerges as a central theme (Lindqvist 2001; Nilsson 2009). These ideas are grounded in the work of Vygotsky (Vygotsky & Cole 1981) and encompass pedagogical theories related to SDL (Garrison 1997; Knowles 1975) and PBL (Freire 2000; Stentoft 2017). Multimodality is another key consideration because PoP involves the extent to which a wide range of different modes, from the arts to games, to digital technologies, are incorporated into play-based activities (Edwards 2013; Kress 2010, 2011; Li 2022; Lindqvist 2001; ed. Olivier 2020; Palaiologou 2016; Vogt et al. 2018).

Several of these theoretical intersections relate to metaliteracy as a comprehensive pedagogical framework and have been applied in practice (Mackey & Jacobson 2022). While these associated concepts have been discussed concerning metaliteracy previously (Jacobson, Mackey & Olivier 2021; Mackey & Jacobson 2022), *PoP* as a theoretical and applied construct has not been thoroughly analysed in relation to this model. Given the conceptual linkages among these core pedagogical principles, a deeper exploration of these ideas is needed to envision the practical design of interactive PoPs through the lens of metaliteracy.

Metaliteracy

As first introduced, metaliteracy was proposed as a *reframing* and *redefinition* of information literacy to prepare learners for social media environments and online communities (Jacobson & Mackey 2013; Mackey & Jacobson 2011). Over time, metaliteracy evolved into a flexible and holistic framework for a wide range of disciplinary settings and pedagogical situations (Mackey & Jacobson 2022). Metaliteracy involves the effective and responsible production of information in multiple modes, from digital stories to diverse collaborative projects and digital presentations (Mackey & Jacobson 2022, p. 1).

The development of metaliterate learners as producers in such disparate learning situations includes a central focus on self-awareness through metacognition (Mackey & Jacobson 2014, 2022). According to Flavell (1979, p. 908), individuals are continuously placed in situations that will 'provide many opportunities for thoughts and feelings about your own thinking to arise and, in many cases, call for the kind of quality control that metacognitive experiences can help supply'. Flavell suggests an ongoing process of metacognitive reflection for individuals to gain insights about their thinking while also self-regulating or taking charge of their learning (Flavell 1979).

From a metaliteracy perspective, self-awareness about oneself as a metaliterate learner supports individuals in gaining more than discrete skills because they gain a better understanding of who they are as learners. As part of this process, they strive toward a *metaliteracy mindset* that prepares them for wide-ranging learning situations and environments (Mackey & Jacobson 2022, pp. 20–21). Reflection is important to this approach because 'a metaliteracy mindset is realised through metacognition and the self-awareness of being an active learner who plays multiple roles to effectively participate in shared communities' (Mackey & Jacobson 2022, p. 20). Individuals gain new insights about who they are as learners as they work toward being fully engaged in their ongoing development. This process involves scaffolding learning through interactions with peers and teachers in social settings (Mackey & Jacobson 2022, p. 43).

Metaliteracy is designed as a flexible, open and integrated model (see Figure 3.1) involving three interrelated spheres of learning – domains, roles and characteristics – that are reinforced through an adaptable set of goals and learning objectives. The *centre sphere* of this model shows the four learning domains, including the *affective*, *behavioural*, *cognitive* and *metacognitive* (Mackey & Jacobson 2022, pp. 23–30). The distinct aspect of each domain and the interrelated nature of these dimensions supports individuals in understanding their learning process better. The *outer sphere* of the model identifies specific metaliterate learner roles, including the

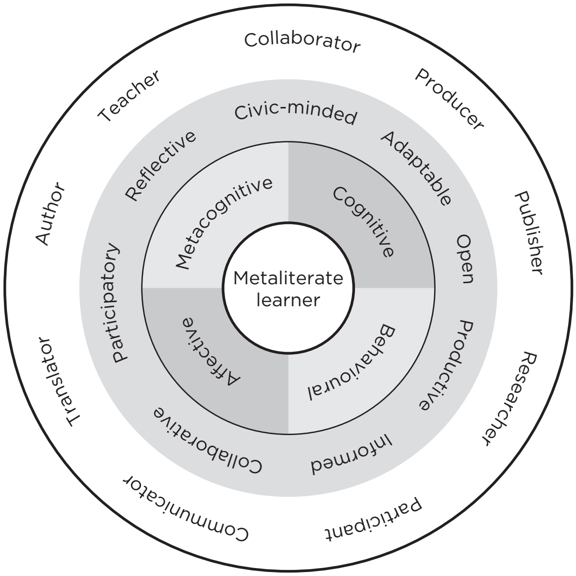

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FIGURE 3.1: The metaliteracy model.

producer, which inspired this approach, along with related responsibilities, such as the *researcher*, *publisher*, *translator* and *teacher* (Mackey & Jacobson 2022, pp. 32–34). The sphere between the domains and roles defines the metaliterate learner characteristics they strive to gain in learning activities. These metaliterate learner qualities or attributes include being productive, collaborative, informative and participatory, emphasising the social dimension of producing reliable information (Mackey 2019, pp. 16–23; Mackey & Jacobson 2022, pp. 30–32). Additional characteristics involve striving to be reflective, open, adaptable and civic-minded, acknowledging several key internal qualities and the responsibilities to one's community.

Metaliteracy is discussed in relation to Malcolm Knowles's definition of SDL and Paulo Freire's concept of problem-posing education closely associated with PBL (Freire 2000; Jacobson et al. 2021; Knowles 1975; Mackey & Jacobson 2022; Stentoft 2017). The model is examined concerning SDL and assessment by analysing a digital badging activity in an Educational Planning course and a Wikipedia editing assignment in a one-credit information literacy course (Jacobson et al. 2021). As a pedagogical framework, metaliteracy combines theories of SDL with metacognition and collaborative learning (Flavell 1979; Knowles 1975). Metaliterate learner roles that include being a participant, collaborator and producer are embedded in this approach as individuals reflect on who they are as learners and how they work with others to support their ongoing development. The metacognitive learning domain is pivotal to this process as self-directed learners reflect on their thinking in learning situations. Additionally, they strive to gain such metaliterate learner characteristics as being reflective, collaborative, participatory and productive as well.

Although the relationship between metaliteracy and PoPs has not been fully investigated, this model is discussed as an impetus for designing a game-based digital badging system based on the metaliteracy goals and learning objectives (O'Brien 2018). The model is also discussed in relation to multimodality because 'the multitude of modes that are available in today's ever-changing social information environment provides teachers and learners with available resources to produce and share knowledge collaboratively' (Mackey & Jacobson 2022, p. 58). Olivier (ed. 2020, p. 18) says that metaliteracy supports 'individual multimodality' because it 'proposes a student-centred aspect where students also act as producers'. The variety of different modes to support the construction of meaning in today's connected world range from such dynamic forms as digital storytelling to virtual worlds and maker-space communities (Mackey & Jacobson 2022, pp. 61–66).

Now that the concept of metaliteracy as a pedagogical framework is established, we will explore relationships between the model's main components and play pedagogies. The intersection of theory will then inform the specific application of this approach in several metaliteracy learning activities.

Learning domains

As noted earlier, metaliteracy emphasises four interrelated domains of learning: metacognitive, affective, cognitive and behavioural. This comprehensive approach encourages individuals to recognise that it is not solely the cognitive and behavioural domains that indicate learning has taken place. Skills- and recall-based understandings of learning focus on these two domains but omit critical aspects of the process contributed by the metacognitive and affective domains.

All four learning domains have a role in PoP, as will be evident in the examples presented later in this chapter. This section considers the domains and their roles in learning in light of PoPs, with its elements of PBL and implications for SDL. Interwoven are connections with selected metaliteracy goals and learning objectives (Jacobson et al. 2018). All references to the goals and learning objectives below refer to this source.

It is important to recognise that experiential learning is an effective pedagogical approach encompassing all four learning domains. It can be incorporated as a core component of play-based learning and to encourage SDL. Experience can enhance motivation and engagement, provoking 'us with wonder and curiosity' (Gibbons 2002, p. 47).

Kolb's experiential learning model is also pertinent to play-based pedagogy. This model moves from concrete experience to reflective observation, abstract conceptualisation and active experimentation (Institute of Experiential Learning 2021). Several studies assess the value of integrating Kolb's experiential learning cycle in connection with game-based learning (GBL) (Buur, Schmidt & Barr 2013; Kebritchi, Hirumi & Bai 2010; Thatcher 1990).

Pitt et al. (2015, p. 1013) address the potential impact of living through learning topics and making memories rather than memorisation: 'This type of learning is attainable in structured educational encounters, where unique experiences are created to trump traditional didactics in their ability to produce lasting memories'. They argue that 'well-designed games [...] should increase student involvement, motivation, enthusiasm and interest in the material, which can lead to an ideal memory-making environment' (Pitt et al. 2015, p. 1014). The experiential aspects of play- and game-based pedagogies will be considered within the section for each domain.

Affective

Immordino-Yang and Damasio refer to the need to go beyond 'the rational' domain of learning. They support a holistic approach and interplay among the domains, as does metaliteracy (Immordino-Yang & Damasio 2016):

> When educators fail to appreciate the importance of students' emotions, they fail to appreciate a critical force in students' learning. One could argue, in fact, that they fail to appreciate the very reason that students learn at all. (p. 40)

Learning is often focused on the cognitive and the behavioural, with these two domains at times closely intertwined. They also explore recent advances in the neuroscience of emotions and the impact that new understandings that the relationship between learning and emotion may have on pedagogy (Immordino-Yang & Damasio 2016, p. 28). One of the problems associated with 'logical reasoning skills and factual knowledge', they conclude, 'is that this type of knowledge is often not what is needed in actual life' (Immordino-Yang & Damasio 2016, p. 39).

Learning through experience, whether real-life or play-based, encompasses much more than simply the rational (or cognitive) domain, allowing students to develop multiple intelligences, such as emotional literacy and interpersonal skills that transfer well to real-world situations (Wingert & Molitor 2015). Kolb's experiential learning model addresses being open-minded and flexible in the concrete experience phase (The Training Thinking 2015), which connects to the affective learning domain.

This domain plays a key role in PoPs. It impacts motivation (Bawa 2019, p. 381), problem-solving and decision-making (Immordino-Yang & Fischer 2016, p. 86). As these are all important elements in the design of play-based pedagogy, it is critical to recognise the importance of building affective elements into play-based units and activities.

The conscious inclusion of affective domain-related elements into the learning approaches aligns well with one particular metaliteracy learning objective – Goal 4 aimed at developing learning strategies to meet lifelong personal and professional goals – that highlights SDL. Within the goal are two pertinent objectives, which encompass flexibility and adaptability, aligning with Kolb's model.

☐ Goal 4: Adapt to new learning situations while being flexible about varied learning approaches

In traditional formal educational models, students beyond elementary or primary school are not often confronted with play-based learning opportunities and may feel uncomfortable in such situations. Recognising the importance of flexibility and keeping an open mind about the value of such a novel approach helps an individual recognise the potential for learning in various situations. Closely connected to the flexibility objective is to adapt to and understand new learning situations while being flexible when using varied approaches to learning.

☐ Goal 4: Adapt to and understand new technologies and the impact they have on learning

The nature of technology is to change, and to be a metaliterate self-directed learner, individuals must recognise that they are capable of mastering new technologies through experience and application. Suppose a selected PoP introduces learners to new online applications and technologies and provides them with the tools to succeed. In that case, individuals will foster a stronger sense of confidence in their ability as self-directed learners to adapt to future technologies.

As we will see in several examples of courses that encourage the production of information, this objective is both affective and metacognitive. It is central to the development of metaliterate learners.

Goal 3: See oneself as a producer as well as a consumer of information

Metaliteracy thus challenges individuals to engage with the affective domain in learning, as is evident in its *goals* and *learning objectives*. Nevertheless, it also allows scaffolding student learning when metaliteracy is explicitly included in a course's content. Open pedagogy is discussed in regards to the scaffolding of learning through metaliteracy (Mackey & Jacobson 2022, pp. 85–86), but it would also apply in play-based learning situations. Both open pedagogy and PoPs introduce a new type of learning opportunity for students, and each has the potential to discomfort students who understand learning primarily from the cognitive domain. When the educational system prioritises the transfer of information from the instructor to the student via lectures, it can be difficult for some students to assume a more proactive role. Learning based on familiar models' cognitive aspects trigger an affective impact when disrupted.

Cognitive

In adult play-based learning activities, it is vital to focus on learning objectives. These objectives should address 'specific themes and narrower topics', which will help teachers to develop their activities (Pitt et al. 2015, p. 1014). Ignacio and Chen (2020, p. 5) analysed the impact of web-based classroom gaming amongst nursing students and described game-based learning as 'a micro-level strategy that facilitates meaningful learning at the session level'. They note that gaming is student-centred and has the ability to 'promote the development of 21st-century skills such as critical thinking' (Ignacio & Chen 2020, p. 5). A mixed-methods research study of business students found that they felt that digital game-based learning (DGBL) helped learn course content and study for exams. Exam scores bore this out (Bawa 2019, pp. 379–380).

Pitt et al. (2015) suggest moving beyond student-centred to student-directed learning opportunities. They argue that 'if student-directed teaching is used correctly, the leader can focus less on teaching facts, and more on facilitating discussion that triggers higher-order cognitive skills such as application and analysis' (Pitt et al. 2015, p. 1016). While not all PBL is student-directed, examples include students developing questions for a 'Jeopardy'-type game. In another example, 'Stump the Class', groups of students design a question involving high levels of critical thinking, which they then pose to other teams in the class (Wingert & Molitor 2015).

In Kolb's model (The Training Thinking 2015), the abstract conceptualisation phase connects to the cognitive domain:

> [*L*]earning involves using theories, logic and ideas, rather than feelings, to understand problems or situations. Typically, the learner relies on systematic planning and develops theories and ideas to solve problems. (n.p.)

According to this model, the affective domain is excised from the abstract conceptualisation phase, though that surgical division may be difficult to apply in practice.

There are many cognitive metaliteracy learning objectives, and they appear in all four learning goals. While it depends on the nature of the play-based activity and the problems students are grappling with, the following are likely related to assorted play-based learning situations. The second is closely tied to Kolb's abstract conceptualisation phase.

☐ Goal 3: Recognise that learners are also teachers and teach what you know or learn in collaborative settings

The nature of the play-based activity will determine whether this objective associated with this goal is pertinent to any given learning situation. Pitt et al. (2015, p. 11) promote the idea of student-directed teaching, and instructors developing activities may build in the chance for students to serve as teachers, allowing them to enhance their learning. Whitman (1988, p. iii) cites studies that 'demonstrate that the cognitive processing used to study material to teach is different from studying to take a test' (Bargh & Schul 1980; Benware & Deci 1984), and 'the peer learners benefit because of the ability of peers to teach at the right level' (Schwenk & Whitman 1984).

☐ Goal 4: Recognise that critical thinking depends upon knowledge of a subject and actively pursue deeper understanding through inquiry and research

While some GBL activities depend upon knowledge of a subject (e.g. a 'Jeopardy'-like game), those activities might simply emphasise recall. Instead, play- or game-based learning opportunities may be designed to highlight critical thinking to buttress an emphasis on the inquiry process.

☐ Goal 4: Effectively communicate and collaborate in shared spaces to learn from multiple perspectives

Many play-based activities involve student collaboration (refer to the 'Play-infused activities for first-year students' section as an example). This means that communication among students, and an openness to multiple perspectives, are vitally important. Students have the opportunity to recognise that these varied approaches and perspectives are beneficial to their learning and their success when a play-based activity is designed accordingly.

Other cognitive objectives will apply in particular cases. As an example, the first-year student case study involves the collaborative creation of an online whiteboard. For that situation, this objective was pertinent: 'Differentiate between copyright, Creative Commons, and open licenses in both the creation and licensing of original and repurposed content (Goal 2)'.

As we will see in the analysis of an upper-level 'Digital Storytelling' course, this cognitive objective also supports learners in producing original digital narratives.

Behavioural

Visual and auditory stimuli, mystery, problem-solving, interaction, outcomes and feedback, and elements that evoke curiosity may be considered within PBL (Woo 2014, p. 293). Keeping these components in mind helps to develop appropriate activities in multiple modes.

In Kolb's experiential learning model, the behavioural learning domain would be evident in both the concrete experience phase as well as the active experimentation phase. Kolb stated (The Training Thinking 2015):

> [*L*]earning in this stage takes an active form of experimenting with changing situations. The learner would take a practical approach and be concerned with what really works instead of simply watching a situation. (n.p.)

Although on the surface this seems somewhat different from the following metaliteracy learning objectives, it actually encompasses the more focused metaliteracy objectives.

Behavioural objectives relating to PBL are highlighted throughout the goals, as seen here from objectives within Goals 2–4:

- Responsibly produce and share original information and ethically remix and repurpose openly-licensed content (Goal 2).
- Share knowledge accurately and effectively through content production using appropriate and evolving formats and platforms (Goal 3).
- Participate conscientiously and ethically in collaborative environments (Goal 4).

As we will see in several examples of metaliterate learning in the second half of this chapter, these goals and objectives play out in multimodal problem-solving activities and the production of individual and collaborative digital media projects.

Metacognitive

Keller (1987), the creator of the attention, relevance, confidence and satisfaction (ARCS) motivation model, recognises that the time for reflection is not during a play-based activity but rather serves a better purpose when it follows that activity. This accords with Woo (2014, p. 292), that a game or playful approach should stimulate individuals in ways that ensure the full focus is on the activity. Following the learning opportunity is the best time for substantive reflection, which might include both group and individual components. The group discussion highlights a variety of perspectives that might provide additional illumination, and the individual provides an opportunity for considering one's own actions and reactions.

Kolb's (The Training Thinking 2015) reflective observation phase of the learning cycle is metaliteracy's metacognitive learning domain, with an element of the affective:

> [...] people understand ideas and situations from different points of view. In a learning situation the learner would rely on patience, objectivity, and careful judgment but would not necessarily take any action. The learner would rely on their own thoughts and feelings in forming opinions [...]. (n.p.)

Kolb's placement of this learning phase after the concrete experience phase follows Keller's recommendation that reflection occurs after the experience or activity.

Two objectives from Goal 4 – 'develop learning strategies to meet lifelong personal and professional goals' – are closely aligned with such post-action reflection:

- Recognise that learning is a process and that reflecting on errors or mistakes leads to new insights and discoveries (Goal 4).
- Assess one's learning to determine both the knowledge gained and the gaps in understanding (Goal 4).

While journaling might accomplish this, it could be built into a play-based activity's concluding component. If the activity were collaborative, the reflective component might be as well. One way would be to use group reflection cards. Learning that occurred during the play activity might be assessed immediately afterwards, or be revisited later in the course, or both. In a digital world, these objectives support online self-assessments and peer reviews of media projects produced and published by learners in the same course.

Learner roles and characteristics

The interrelated learner roles of the metaliteracy model are aspirational responsibilities to support the development of active knowledge producers

(Mackey & Jacobson 2014, 2022). The specific roles, such as the researcher, producer, publisher and author, reinforce an individual's ability to contribute to dynamic information environments. The social dimension of these spaces requires related roles, such as the collaborator, translator, participant, communicator and teacher. Embedded in the model is the concept that individuals are both learners and teachers because learning itself is a dialogic and social process (Freire 2000; Mackey & Jacobson 2022; Vygotsky & Cole 1981). As part of this holistic framework, a set of characteristics unifies the model by defining the qualities or attributes that self-directed learners reach toward as a part of learning activities. Several of the characteristics emerge directly from the learner roles, such as productive (producer), informed (researcher), collaborative (collaborator) and participatory (participant). In addition, related characteristics such as being open, adaptable and civic-minded encourage learners to develop qualities that prepare them for responsible engagement with individuals in contentious or divided information environments (Mackey 2019; Mackey & Jacobson 2022).

The relationship between role-play and PoPs has been explored as an area of interest in research, offering potential synergies with metaliteracy's roles and related characteristics. For instance, Brom et al. (2016, p. 339) examine team-based role-play in DGBL environments and found that 'team role-playing contributed to an increase in positive affect and flow; and perhaps, in turn, in learning gains'. In a qualitative study, Rogers and Evans (2007) interviewed teachers about their use of role-play in classes with children only between four- and five-years-old. Their research suggests that 'role-play is valued highly by both children and adults, and it can make a significant contribution to the development of young children' (Rogers & Evans 2007, p. 154). The authors argue for 'a more critical pedagogy of play' that 'encourages children's participation in the construction of pedagogical practice' (Rogers & Evans 2007, p. 154).

The idea of a 'critical pedagogy of play' reinforces the metacognitive dimension of metaliteracy to continuously think about one's own thinking in ongoing learning situations to gain new insights about the roles learners play to construct knowledge and make meaning. This finding aligns with the aim of metaliteracy to develop self-directed learners who identify and strive toward active roles as knowledge producers (Knowles 1975; Mackey & Jacobson 2022). It supports Knowles' definition of self-directed learners who are fully engaged in all aspects of their learning and Freire's approach to problem-posing education by working in dialogue with peers and teachers (Freire 2000; Knowles 1975). It also supports Stentoft's (2017) definition of PBL as a process of active knowledge production. From a metaliteracy perspective, learners recognise their roles and strive toward or focus on those that require further development. Similar to the findings of Rogers and Evans, metaliteracy is about learning in social settings that require active participation from teachers and learners, especially because metaliterate learners play both roles. Providing opportunities for learners to practice metaliterate learner roles in learning activities while developing associated characteristics through ‘a critical pedagogy of play’ offers considerable potential to advance dialogue, self-direction and PBL in social settings.

Applying holistic strategies for multimodal pedagogies of play

When considering how best to introduce PoPs through a holistic metaliteracy model that involves PBL and SDL, key considerations that apply to all pedagogical situations must be considered. Both identified learning objectives and the need to meet students where they are in their academic development are important to consider. Depending on the specific pedagogy to be employed, students’ levels of expertise in their major subject may also be an indispensable factor. This section examines strategies that have been applied in both upper and lower-level courses. In these different contexts, lower-level courses are usually introductory and offered in the first two years of study, while upper-level classes are advanced and expand far beyond foundational concepts.

These examples illustrate not only the holistic metaliteracy model as examined in the metaliteracy section but also the ability of PoPs to incorporate the other themes of this book: PBL and SDL. There are two play-infused activities for first-year Bachelor in Education (BEd) degree students and two for more advanced BEd students. While the play-related components vary from an actual game to the production of multimodal digital media projects, they all encourage students to engage with their learning in ways that allow them to shape either the outcome, in the case of a ‘BreakoutEDU’ game or what they produce.

Play-infused activities for first-year students

The first two pedagogical examples were developed for use in a required first-year course, ‘Writing and Critical Inquiry (WCI)’, taught at the University at Albany, State University of New York (SUNY) Empire State College, United States of America (USA). The WCI course strives to encourage students to recognise, practice and develop a lifelong habit of engaging in inquiry and critical thinking (Detwiler, Jacobson & O’Brien 2018, pp. 62–63).

Explored here are class sessions that are the product of a years-long collaboration between the two information literacy librarians and one of the WCI instructors. Other course themes include developing a growth mindset and emphasising learner roles as participant, collaborator and producer. The librarians join the WCI instructor and students for up to four class periods during the semester and participate in developing accompanying assignments and writing prompts to support student learning in the class sessions.

Collaboration and problem-solving

The WCI classroom activities, a locked-box adventure and the development of an open online resource that explores a growth mindset, were carefully designed to meet the programme and instructor's goals. The first of these goals focused on developing a growth mindset, the second was to address the course theme of inquiry, and the third was to help develop team cohesiveness (Detwiler et al. 2018, p. 63). These activities were designed so that student groups would learn from one another as they worked through the challenging tasks they were given. The problems were representative of real-world issues, distilled for the setting of this course. The inquiry process and developing a growth mindset are abstract but crucial for lifelong learning and personal growth.

These activities were used in different semesters. They are quite different, but both require students to work collaboratively, during which they develop problem-solving skills in order to be successful.

The WCI instructor learning team was aware that because this class was jointly taught in the early part of the semester, students were still acclimatising themselves to many social, academic and personal factors. Both activities were designed to factor in the changes and disequilibrium experienced by the students. They were specifically designed to be used in preparation for the course elements that followed. The students are not just told about the importance and benefits of collaborative learning; they have the opportunity to experience it. This experience is quite intensive in the actual game. In the online whiteboard project, it is present, but to a lesser degree. The course instructor reintroduces key elements from this early class session at appropriate points during the semester to remind students how course goals were addressed and reinforce their accomplishments during that class period.

Locked-box game: *BreakoutEdu*

In a *cooperative* learning situation, students' goal achievements are positively correlated; students perceive that they can reach learning goals if and only if the other students in the learning group also reach their goals.

Thus, students seek outcomes that are beneficial to all those with whom they are cooperatively linked. (Johnson & Johnson 1990, p. 104)

This quote exemplifies the collaborative and cooperative problem-solving elements of a playful activity used for a number of semesters with WCI students. Based upon the escape room model, generally impractical in a classroom or online class setting, *BreakoutEDU* (Breakout, Inc.) asks groups of students to decipher clues to break into a locked box. It is worth noting that while this section limits itself to the classroom setting, *BreakoutEDU* is also available as an online activity. The online version is transferable to many different instructional scenarios as well.

The kit can be used for a wide range of purposes and topics. Storylines can be created from the ground up, or users of the kit can turn to ideas shared by others. The WCI storyline involved helping the school mascot find his way around campus, just as the students were doing. As they learned about the university library, the students were also developing some basic skills. Clues for the five locks were scattered among the materials the instructors included in the backpack (rucksack) with the game pieces. They were not highlighted in any way. Groups would primarily work as one full or a couple of smaller groups, but sometimes a student would go off on a hunch and work solo. The most successful groups were those that checked with one another throughout the process.

Each time student groups thought they might have found a clue based on a specific lock configuration (text, numbers or arrows), they would try it out. Groups that successfully opened all the locks would find a letter of congratulations inside with some sweets. The instructors' goal was to spur internal, rather than external, motivation, but there was also the desire to reward students for their persistence.

There were just two to three groups per class section, and the instructors could observe student interactions within groups closely. Only one student ever completely opted out and for reasons that were never entirely clear or explicitly stated. The range of enthusiasm within the groups varied, but most got into a competitive spirit and wanted to succeed. What the instructors observed showed the truth of this observation: 'When individuals get stuck, they are more likely to give up, but groups are much more likely to find ways to keep going' (Johnson & Johnson 1990, p. 104). Based on our observations, groups of students usually arrive at the same conclusion as the authors fairly quickly.

As groups opened the lockbox, the instructors would give each group two cards with reflection questions at the end of the allotted time for unsuccessful groups. Some came with the kit, while the teaching team developed additional ones. In the autumn of 2017, these were the questions we asked groups:

- Did you take any risks during the game? Why or why not?
- How did your group utilise each individual's strengths?
- What did playing this game tell you about yourself and your teammates?
- Describe a moment when your team became frustrated. How can you avoid that next time?

After the groups had several minutes to think about and discuss their responses, the instructors would ask each group to share those ideas with the class. Not every group was given the same questions, but the instructors did ask the others for some on-the-spot responses when the original group had finished giving their answers.

The reflection questions consistently generated on-topic discussions that engaged students. Their responses generally indicated that they were happy to have a group to rely upon and often described how they interacted with each other to increase success. Taking time to ask students to reflect on the role of the affective domain in new learning situations helps to magnify its impact and increase the chance that learners will react positively in other learning scenarios. Familiarising learners with metaliteracy will ground this metacognitive activity in the broader framework.

While one class session is insufficient to encourage students with a fixed mindset to accept the value of a growth mindset, having a session focused on this goal provides an opening for the instructor to return to the topic during the semester, helping to address this course goal.

BreakoutEDU centres on inquiry, and the WCI instructor would make this connection explicit on game day and subsequent classes. It gave students an innate connection to this core course activity. The third goal, group cohesiveness, was aided by the game. Students were immersed in working with their group teammates during a challenging activity. Generally, they recognised that they were all working towards the same goal and could trust one another. The sense of play in the room focused on the three session goals and underpinned by core components of metaliteracy, provided an energetic start to the course. Students realised that what seemed daunting at first was potentially a series of problems they could solve working together.

The teaching team also tried a second activity with students during autumn 2021 and spring 2022. While it was designed to meet the same learning objectives, another one was added, focused on the metaliterate role of the learner as producer.

Collaborative creation of an online whiteboard

Starting in the autumn 2021 semester, the WCI instructor and librarian team moved to a new activity to have students collaborate as information producers to create an online whiteboard representing a 'growth mindset'.

However, because this activity takes place in the first week of the semester, the instruction begins with content specific to the idea of a growth mindset and metaliteracy. The goal is for students to be conscious of their thought processes, emotions and behaviours as they engage in what is, for many of them, a process encapsulating some tensions: working closely with and making decisions with students whom they do not know. At the same time, they are also trying to assess the other students' commitment to the idea of a growth mindset as they develop the collaborative whiteboard.

Before the class started, students worked through several online metaliteracy activities, including one called 'Failing Better' (O'Brien 2018, p. 192). They are introduced to Dweck's work on growth mindsets (2008), and at the end of the activity, they were invited to add their story of having actually failed better at some point in their life to an online wall. They are able to see what others, over the course of a number of years, have written about their own 'failing better' moments. This activity is just one of many to be found in the Metaliteracy Badging System project (Metaliteracy Learning Collaborative 2014). They are also assigned a short reading on metaliteracy. Students are invited to share a few of their 'Failing Better' responses in class. The four metaliteracy learning domains are explored, and then groups of students are asked to assess how their assigned domain impacts their learning. First, the students discuss the metaliteracy roles and their application in the course. They then continue to work collaboratively in a play-based activity designed to address course goals connected to developing a growth mindset, learning how to differentiate between open versus copyrighted content, and the learner as producer.

The activity prompt they are given is controlled yet challenging. The control is provided via the given topic – a growth mindset – and the designated, and most likely unfamiliar, tool – a Google Jamboard. While they are creating the Google Jamboard collage, which allows for disparate content, they are sensitised to the roles of communicator, collaborator, researcher and producer. This awareness encourages them to work more collaboratively, even though they all use their own computers while doing group work. They help each other to determine whether items are under an appropriate Creative Commons (CC) license and, therefore, applicable. Students frequently teach their classmates, both within and across groups, platform features or how to find copyright-free images.

At the end of the time allowed for this activity, the instructors asked each team to present their Google Jamboard. Their pride in their teamwork is clear, as is their support for team members who have created or identified elements that are out of the ordinary. This debriefing allows time for groups not only to discuss their co-created Google Jamboard but also to begin to reflect on how this activity connected with the metaliteracy learning domains and roles and with a growth mindset. Based on the findings of Keller (2008) and Woo (2014), they are situating the reflection after the activity as is done with these students.

Play-based activities in upper-level courses

As we have seen, metaliteracy supports SDL through interactive activities that employ elements of PoPs in foundation courses at a lower level. This flexible pedagogical framework informs the design of collaborative social learning and meaning-making in upper-level courses as well. This section explores two advanced-level courses, 'Digital Storytelling' and 'Ethics of Digital Art and Design', at the SUNY Empire State College, New York State, USA. These fully online courses prepare self-directed learners to embrace several interrelated metaliterate learner roles, including researcher, producer, collaborator and teacher, as they construct knowledge through interactive learning activities in multiple modalities.

Course: 'Digital Storytelling'

The fully online course, 'Digital Storytelling', is integral to the Digital Arts curriculum in the Department of Arts and Media. It is designed for a wide array of students from multiple disciplines.

The learning objectives of an earlier version of this course were analysed concerning the original broadly defined learning objectives introduced in the first metaliteracy article (Mackey & Jacobson 2011, pp. 70–76, 2014, pp. 185–206). A revised version of this course has been updated as a collaborative online international learning (COIL) experience to connect faculty and learners from Europe and the USA based on an international partnership at SUNY Empire State College (Mackey & Aird 2022). This global course integrates metaliteracy into several learning activities in support of self-directed learners who apply the theories and techniques of digital storytelling.

The course scaffolds learning about digital storytelling and metaliteracy based on feedback from peers and faculty. Students develop several individual digital stories, including an introductory selfie-video, a mobile story, a digital narrative about empowerment and a final selfie-video.

They plan the stories by writing scripts, developing storyboards and applying openly available digital tools. Thoughtful planning informs the construction of three- to five-minute narratives that combine multiple modes such as digital images, video, audio narration and background music. As part of this process, they learn about CC licensing and are required only to use original digital images and video or to repurpose openly-licensed materials. In addition, they write peer reviews for their classmates based on the same digital storytelling rubric applied by the course instructors. The course culminates with a final collaborative project about a relevant social issue that students plan and produce together in small groups.

The course, 'Digital Storytelling', incorporates the metaliteracy framework into several learning activities based on an interactive version of the metaliteracy diagram (Mackey, Jacobson & O'Brien 2020). The dynamic metaliteracy framework introduces learners to the learning domains, learner roles and characteristics, and links to related questions. Each question allows learners to reflect on their relationship to the different components and is tagged with the most relevant domain to show how the model is interrelated and holistic. The integrated model moves and spins as the learner engages with it, and all of the components include dynamic links that allow the learner to investigate the concepts on their own and at their own pace.

Throughout the course, students are in dialogue via three online discussion forums about issues related to digital storytelling and through peer reviews associated with each project. As part of the first selfie-video assignment, they are asked to explore the interactive metaliteracy diagram, describe the metaliterate learner roles that they identify with the most and explain why they made these selections. They build this analysis of the learner roles into the video and begin to reflect on who they are as learners. This assignment embodies several key roles, such as being a collaborator, participant and producer, while asking students to consider which roles they recognise in their own lives. The next assignment is a mobile story in which learners reflect on how their mobile devices impact their storytelling production. They watch a metaliteracy video about producing digital narratives that reinforces the learner roles while providing the essential elements of creating an effective digital story as a metaliterate learner (Telling Your Digital Story 2019). The next assignment explores the theme of empowerment, which embodies metaliteracy as a pedagogical framework for inspiring self-directed learners to take charge of the narratives they design and construct.

This final project involves social learning through a team-based assignment that requires planning and producing a digital story about a social cause. The teams identify a specific social issue to advocate for, such as climate change, anti-racism efforts or social justice, and then develop a collaborative script and storyboard to produce a digital narrative. As part of this process, they identify production roles, such as a scriptwriter and storyboard creator, media producer, narrator, on-camera (on-air) talent, editor and publisher, complementing the metaliterate learner roles. They also teach each other about information and communication technologies (ICTs) and other digital tools, research discoveries and digital storytelling production. In a related assignment, they engage in an online discussion about collaboration by answering questions from the interactive metaliterate learner figure about the collaborator role. As a result, learners analyse the importance of effective collaboration in team projects and reflect on their many different experiences with teamwork in their own lives.

The last learning activity in 'Digital Storytelling' is a final selfie-video for students to assess their learning based on the metaliteracy learner characteristics. They review the integrated model and respond to the questions posed in the characteristics sphere. As part of this closing assignment, they fulfil the vision for SDL by Knowles (1975) to not only take charge of one's goals, identify resources and develop strategies but also to evaluate one's learning (Knowles 1975, p. 18). Through this reflective activity, they have the chance to see themselves as producers of information, a key objective of metaliteracy, that is realised through the meaning-making of their own personal narratives (Jacobson et al. 2018; Lindqvist 2001; Nilsson 2009).

Course: 'Ethics of Digital Art and Design'

The 'Digital Arts' curriculum at SUNY Empire State College addresses the responsibilities of producing and sharing digital media art through the course 'Ethics of Digital Art and Design'. It was first developed as an international blended residency in Cyprus, combining online and in-person instruction, and was then redesigned as a fully online offering (Mackey 2021). However, while the current iteration of the course does not engage with metaliteracy learning materials as directly as 'Digital Storytelling', the conceptual framing of metaliteracy undergirds the entire course.

The description and learning objectives for this intensive study of ethics are influenced by metaliteracy to prepare reflective and informed learners who actively evaluate, produce and share digital art. In addition, the primary learning activities require learners to develop several multimedia publications using the *Linkr Education* platform (Linkr Education [Linkr Media Inc.] 2022). This work is reinforced through related online discussions based on openly available readings and resources.

Further, students in this course engage in a culminating group assignment to research and produce a digital media project that addresses a relevant topical issue related to ethics in the digital arts. Throughout the course, students teach and learn from each other in this collaborative setting as they engage with their peers in discussions and respond to each other's Linkr multimedia publications.

Each of the assigned multimedia publications in Linkr addresses a specific ethical issue explored in the course modules. The first Linkr assignment explores the impact of digital media on our understanding of reality as explored in the work of the artist, designer and technologist Jiabao Li (Li 2022). In the second publication, students produced an original digital image that examines the issue of digital manipulation in digital photography through the study of the artist Cindy Sherman (Museum of Modern Arts [MoMA] 2022). The third Linkr publication explored anonymity related to the artist Banksy and the larger societal issues he raises in his art (Banksy 2022). As the course progresses, they also write about and produce digital images related to the challenges associated with defining objectivity in documentary photography and the ethical concerns of deep fake technology and the emerging metaverse.

As self-directed learners, the students in this course scaffold their learning about these ethical concerns based on feedback from classmates and the instructor. They contribute to a process of meaning-making through the production of digital images and text that constitute their multimedia publications. As the students complete each publication, they also see that their contributions are automatically organised into a digital portfolio in Linkr that emerges from this process. In addition, the larger class space in this shared platform reveals all the publications from everyone in the course. This incremental process unfolds over time and reveals the collective contributions of all students as metaliterate researchers, producers and publishers. In many ways, each assignment is an ethical problem to be solved, or at least examined thoroughly, to reinforce a more profound understanding among all of the course participants. The culmination of this work embodies the ethical responsibilities of information producers that is so core to metaliteracy.

Conclusion

This chapter has examined play-based pedagogy, particularly concerning PBL, SDL and multimodality. The interconnections among these pedagogical concepts suggest that combining elements strengthens the opportunities for student learning. The chapter introduces a new component, metaliteracy, that overlaps and extends the conversation about the PoP as a dynamic construct for teaching and learning. Connections are made between core components of metaliteracy, PBL or GBL, SDL and multimodality, suggesting a powerful yet easily adaptable teaching and learning strategy. Examples that have proved effective with students in courses at different levels illustrate how this might be implemented. However, the learning activities presented in this chapter are meant only as jumping-off points to inspire further investigation into the application of these ideas.

Chapter 4

Joyful learning: Advocating for self-directed learning through authentic, playful problem-based learning

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Abstract

This conceptual study explains how playful problem-based learning (PPBL) could promote joyful learning experiences, to enhance self-direction and well-being in school contexts, including and beyond early childhood. In recent years, the relevance of play in the educational process has received more attention, particularly pertaining to learning beyond early childhood

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development (ECD). Younger generations seem to desire fun and excitement and tend to rebel against inequality. Furthermore, there has been growing attention given to the need to develop 21st-century skills. We argue that a focus on playful learning may contribute to young people having fun while engaging in authentic teaching and learning activities and feeling inspired and motivated to learn. In addition, problem-based learning (PBL) allows learners to engage in collaborative teaching and learning activities with real-life value.

If teachers promote PPBL, they could create adventurous learning environments where learners are encouraged to take risks, with the assurance that it is safe to do so. Learners will consequently be actively involved in fun, authentic teaching and learning activities that call for curiosity, problem-solving and social interaction through playful learning. Through these activities, learners can appreciate various ways of knowing and learn more about their strengths and preferences. During these PPBL activities, learners could develop their identities and understand their roles within their communities. By implementing PPBL, teachers have the opportunity to transform learning and foster creative and self-directed learning (SDL) environments where learners are not afraid to take risks, can develop problem-solving mindsets, are innovative and feel motivated.

Within a PPBL environment, we believe that teachers and learners can continuously learn self-directedly, motivated by their interest in learning and their desire to experience a sense of belonging. Therefore, educators in PPBL environments need to cultivate a positive attitude towards fostering SDL skills within each learner's capacity so that learning can be experienced as a meaningful activity. Furthermore, within these PPBL environments, teachers must create fun, authentic and meaningful learning opportunities that enable learners to flourish.

■ Introduction

This chapter aims to explain how authentic PPBL could promote joyful learning experiences and enhance self-direction in school contexts, including and beyond early childhood. This chapter is informed by social constructivism as defined in Chapter 2 and is, therefore, embedded in the principles of learners constructing knowledge actively; learning occurs through social interaction and is a human activity. Furthermore, learners create meaning through interaction with others and their environment, collaboratively solve problems and reach new ways of understanding. The chapter is informed by social constructivism and is justified by the fact that it could be applied through instructional methods such as PBL and develops independent problem-solving skills, which is vital for SDL. Ultimately, the aim is that learners become active co-constructors of knowledge through self-directed PPBL (Dorgu 2015; Kapur 2018; Shah 2019). Our focus, therefore, is on describing the nature of learning and the classroom atmosphere in teaching and learning environments that will be conducive to PPBL. Finally, we will explore the basic characteristics of PPBL by focusing on how these teaching and learning activities could promote a sense of belonging, joyful experiences, authentic and meaningful learning, and flourishing. Although PPBL is not explicitly defined in the literature, we drew from Barrett's (2005) work on how PBL can be fun and enjoyable and support the acquisition of 21st-century skills in higher education (HE). In this chapter, we define PPBL as experiences where learners engage in authentic, playful activities that are informed by PBL.

Much research has been done on PBL over many years (see ch. 1), including the various characteristics associated with PBL and SDL. Knowles' (1975) definition of SDL, as referred to in Chapter 1, was also used as the working definition of SDL in this chapter. Without going into considerable detail regarding PBL and its connection to SDL, we argue that it is essential to highlight some critical aspects of PBL to provide the context for this chapter and the background against which we wrote this conceptual study. These aspects, which are derived from the work of Savery (2015), include, among others, that (1) learners need to take charge of and be accountable for their learning, (2) diverse disciplines or topics should be included in the curriculum and (3) working together is critical. Moreover, (4) the knowledge that learners acquire via SDL has to be applied to problems that need solving, which involves re-evaluating and finding a solution to the problem. Furthermore, (5) conducting a concluding analysis of the knowledge gained and the ideas and principles discovered while trying to find a solution is vital. Subsequently, (6) learners should evaluate themselves and their peers after solving a problem and completing each curricular unit. Lastly, an essential characteristic is that (7) the activities carried out in PBL must have real-life value.

The aforementioned PBL characteristics highlighted align with the discussions that follow, which are about learning with, from and through others and collaborating in solving challenging problems that relate to real-life. The PBL characteristics also support motivations to create a classroom climate that allows for PBL through play-based learning to boost learners' ability to function as self-directed individuals (Barrett 2005). We argue that playful learning experiences could contribute toward learners' intrinsic motivation to solve the complex real-life problems they engage with during PBL activities. Providing learners with a teaching and learning environment immersed in real-life contexts is a crucial component of such an approach in education. Therefore, contextual learning could support PPBL as it creates opportunities for learners to engage with and solve meaningful real-life problems within these contexts.

From the above, we believe that contextual learning is not limited to area and location, as that may exclude, for example, a person's identity and abilities, to name a few. However, the content must be familiar to learners (De Jong 2006), meaning their prior knowledge must support the new information and skills they learn. This latter notion supports the idea that pedagogical decisions promote or inhibit contextual learning (cf. Leite 2017). Therefore, we concur with Overton (2007) that PBL could be part of contextual learning as it provides opportunities for learners to engage in authentic learning activities within meaningful contexts. This argument necessitates discussing contextualised learning environments and how they support the PBL characteristics, as mentioned earlier.

Contextualised learning environments

Contextualised learning environments in this chapter comprise education that places learners at the centre of class activities. Doing so requires that learning is based on group work. Learning should be reciprocal and vicarious, but through an engagement with the learning content, the learner should be able to identify themselves in what they learn (Leite 2017), which might increase their motivation to learn (Bennett, Lubben & Hogarth 2007).

Learning *with*, *from* and *through* others

This section is twofold. Firstly, it is focused on learning *with* others. Secondly, we address aspects of learning *from* and *through* others, which resemble how social-constructivist and cognitive learning theories underpin learning. Thus, the discussion in this section revolves around how learning in a PBL environment occurs *with* other learners, *from* other learners and *through* other learners. We believe that, as they develop, the learner goes through a process (resembling a journey) that continues for their entire life. Ultimately, learning with, from and through others could promote SDL to deliver self-directed individuals (the product). We maintain that, through PPBL, learners get the chance to learn, unlearn and relearn[1] in a learning environment where they can have fun while also generating solutions to problems they may face at the current moment or in the near future.

Learning *with* others

In this chapter, the activity of learning *with* 'others' is based on the idea of learning together – in other words, constructing knowledge together

1. By learning, unlearning and relearning, we mean that individual's pre-existing knowledge is challenged so that their preconceived notions of a topic are dismantled and replaced with more nuanced and diverse ways of thinking about the same phenomenon (cf. Klein 2008; Tome 2021).

(Du Toit-Brits, Blignaut & Mzuza 2021). The social-constructivist theory of learning asserts that human progress is socially situated and that knowledge is generated via contact with others, which is exemplified through collaboration and the formation of common understandings of events (McKinley 2015). The emphasis, therefore, is on the learning that occurs within the learner, based on their participation within a learning community. As a consequence of this collaborative learning, learners can extrapolate and disseminate the information they gain in a lesson via participation in a group conversation, which helps them develop a firm social basis to convey their thoughts about solutions to a problem verbally (McKinley 2015; Reznitskaya, Anderson & Kuo 2007). Through collaborative learning experiences, understanding is developed through recognising a problem and a learning need, looking into it and finding a solution based on how previous experience has shaped cognition (Myburgh & Tamarro 2013). Learning and finding knowledge together implies learning more than one would have learnt alone. Individuals acquire more information and improve their ability to communicate verbally and non-verbally because of the many interactions that occur when exploring together for answers to issues and learning needs (Arslan 2018). Thus, learning with others within one's context adheres to the PBL and SDL characteristic that requires group work to solve problems in educational settings (Du Toit-Brits et al. 2021).

Learning *through* and *from* others

Learning *through* and *from* others resembles learning first-hand or second-hand through the actions of someone who is also part of a community (cf. Gelman 2009; Harris 2012; Vygotsky 1978, 2012). This type of learning is congruent with the social cognitive view of learning and is twofold – learning happens by repeating behaviour that took place, or learning happens by altering behaviour that occurred where the desired outcome was not reached (Woolfolk 2016).

Learning through each other, also known as observational learning, is a process where learners observe one another employing their engagement and then derive knowledge from those observations (Ormrod 2017). This type of learning occurs as learners interact with course materials and resources and communicate about possible solutions to problems. In addition, learners act as models for one another, which is how they learn new things; by acting as models for one another and demonstrating to one another how to carry out specific tasks or how certain problems may be addressed (Ormrod 2017). Within PPBL and collaborative learning contexts, social interactions could emerge among learners while engaging with content. Within these interactions, learners could benefit from discussing various understandings of real-life problems to formulate solutions to these complex problems. Moreover, these interactions provide learners with essential opportunities to learn through each other and from each other constructively (Hendarwati, Nurlaela & Bachri 2021). In other words, learning occurs in such a manner that learners can form understandings based on what they learn and experience from each other.

Learning from each other is associated with enactive learning, otherwise known as vicarious learning, which would consist, for example, of discovering something by seeing how the actions of another person play out in the world (Schunk 2016). The behaviours that lead to successful rewards are kept in place, whereas those that lead to failed outcomes are changed or abandoned outright. Learners can, therefore, acquire knowledge by observing the actions of others during a process known as vicarious learning (Bandura, Ross & Ross 1963).

We believe that allowing learners to learn with, through, and from their peers can enhance the development of the key abilities required for PBL and SDL (cf. Hurst, Wallace & Nixon 2013; Lizcano-Dallos, Vargas-Daza & Barbosa-Chacón 2019; University of Birmingham 2022). Among the many advantages cited by these sources is the enhancement of proficiency in PBL and SDL in the classroom. Some examples include encouraging literacy in relevant fields and learners learning to think critically and solve problems (Hurst et al. 2013). Furthermore, learning through social interaction increases one’s abilities in organisation, delegation, communication, cooperation, leadership and the ability to follow others (University of Birmingham 2022). Learning with, through and from others helps cultivate rational thought and arguments, boosts leadership potential, and emphasises the significance of social connection and communication (Lizcano-Dallos et al. 2019). In a broader sense, these abilities include group work, managing learning tasks, acting autonomously, applying self-discipline, being open to constructive feedback, engaging in evaluation and reflection, engaging in critical thinking, being accountable, solving problems creatively and communicating effectively (Kumashiro 2000). Learners, through their engagements with the learning content, resources and one another, are allowed to communicate verbally and non-verbally; they work together as a group; and, most importantly, in the process of testing what solutions work, creativity, critical thinking and self-direction in learning are promoted through fun activities and through the adaptations and decisions that they make (Hendarwati et al. 2021). This implies that when learners are given problems that need solving, they will not only solve these problems alone or as a collective; instead, problem-solving will be done in a manner where they seek solutions from multiple perspectives and multiple possibilities underpinned by the idea that every learner brings something unique to the table.

However, we argue that learning *with* others, learning *through* others and learning *from* others is insufficient for contextualised education within a learning environment focused on PPBL and SDL. Moreover, we hold that learners must acquire knowledge about themselves via education centred on them and designed specifically for their learning needs and personal goals.

Individualised learning: Learning that is *for* me and *about* me

Learning, or being exposed to opportunities to learn – such as through content about the learner or specifically designed and developed with the learner in mind – is important for the learner because they ought to be reflected in what they learn. For this discussion, we have used the notion of anti-oppressive education (AOE) by Kumashiro (2000). The four fundamental tenets of Kumashiro's notes that education that is non-oppressive should (1) be for and (2) about the other, (3) criticise the privilege that some people enjoy and the dehumanisation of people, and (4) alter the learner and the community.

Education *for* the other is epitomised by the idea that the learning process no longer captures a person but instead liberates (Freire 1993; Kumashiro 2000). Offering such education matches the characteristics of PBL and SDL in that education for the other can empower the learner to take responsibility and be accountable for their learning. Therefore, learners can understand that they are appreciated and that the challenges they experience daily are, to a degree, included in their education. Through PBL and SDL, learners ultimately seek solutions to the challenges of improving their lives.

In education *about* the other, emphasis on 'othered' persons necessitates teaching all learners about the 'other' (Kumashiro 2000) because everyone experiences 'othering' or exclusion. From this point of view, education has the potential to take on a contextual quality because learners will gain knowledge and skills about individuals who are often overlooked and whose experiences and methods of operation are not typically considered genuine. Furthermore, while working as a group, learners communicate, search for and generate answers to issues. They have the chance to be exposed to the opinions of others, especially those peers who may not be as willing to answer questions or feel silenced because they are viewed as 'different' or less valued (Du Toit-Brits et al. 2021).

Providing learners with learning opportunities to discover their role within a social structure where they are alienated and benefitted helps them understand how their lives are intertwined with those of others. Through reflection, learners become aware of how their *privileges may* *oppress their peers* (Kumashiro 2000), including how they think, the reference points they draw inspiration from or the solutions to problems they generate. Therefore, individual and societal change can only be achieved through an education where learners are made aware of the problems that their fellow citizens face (Kumashiro 2000). Because of this kind of education, learners (and educators) may be confronted with their preconceived notions or assumptions. However, more importantly, learners may realise that every learner has a voice and should be allowed to express themselves in safe academic engagements that are a requirement for the successful completion and learning of tasks. Although they may feel exposed, they can also develop a heightened awareness of their assumptions about the knowledge they possess. Doing so makes it possible for the educator and learners to understand one another better.

Learning with, from and through the other, as well as education for the other and about the other, are geared towards challenging the status quo for *individuals and societies that strive* or *need to be transformed*, thus enabling learners to learn together as a collective (Kumashiro 2000). Moreover, learners can assess what they learn and know, unlearn what they know together and separately; but most importantly, relearn on a continuously negotiated basis during the various interactions that occur while learning (cf. Klein 2008; Tome 2021). Although Kumashiro's notion of AOE did not aim to advance PBL or SDL, it does. By learning with others, from others and through others, SDL skills are developed, and by implication, these skills can be used when learners engage in PBL (cf. Hmelo-Silver 2004). We believe that learning, with others, from others and through others expands one's knowledge base but also one's ability to do things practically or perform practical tasks, which can significantly enhance learning, especially in PBL, where learners have to solve real-life problems.

Contextual education is, therefore, focused on how learners engage in learning activities both individually and collaboratively, which aligns with the characteristics of social constructivism, PBL and SDL. Because the type of education represented in the discussions above is centred on and relevant to learners, they should be motivated to engage and take pleasure in the learning process. Learning environments prioritising the learner and having their best interests at heart are associated with an ethic of care (Joorst 2021). However, contextual education is only successful, bearing in mind that a constructive and encouraging classroom atmosphere needs to be created by the educator. This latter notion emphasises the central notion of human nature in the learning process, which depends on the educator and learner interacting with each other to offer individualised learning as opposed to adaptive learning that is underpinned by technology monitoring learner progress, among others, to determine the way forward for learning to take place.

Creating a constructive classroom atmosphere for learner-centred learning

Studies have shown that a classroom focused on learner engagement can be more constructive, as teachers must find approaches to engage all learners (Allen, Vella-Brodrick & Waters 2016; Allen et al. 2018, 2021; Arslan & Duru 2017). A classroom atmosphere that promotes learner-centred learning is crucial for learners to learn and develop optimally (Arslan 2021; Arslan, Allen & Ryan 2020). Creating a classroom atmosphere that promotes learner-centred learning takes effort from both the teacher and the learners. We believe that teachers can change their classroom atmosphere into an enjoyable, encouraging and supportive learning environment by setting a positive example, implementing social constructivism principles, PPBL skills, joyful learning and building trust – to mention only a few.

When we look deeper into what a classroom atmosphere entails, it involves the attitudes, mindsets, feelings, thoughts, standards, ideas and climate that teachers and learners may experience in their classroom (Arslan 2021; Joorst 2021). On the one hand, for example, learners can experience a hostile classroom atmosphere when feeling confused, intimidated, restrained and unable to take ownership of learning. On the other hand, learners can experience a positive classroom atmosphere when they have fun, where they can be authentic, have the freedom to be silly and often laugh – all while also feeling safe and protected, respected, recognised, valued, accepted, encouraged and supported in their learning (Arslan et al. 2020).

Furthermore, as the teacher frequently sets the tone in their classroom, learners must be motivated, organised, self-directed, confident and caring (Joorst 2021). Drawing on an extensive range of sources (cf. Allen et al. 2016, 2018, 2021; Arslan & Duru 2017), we maintain that a supportive classroom is a learning environment in which a learner has a secure place to connect to learning, is driven to be autonomous and to belong, is permitted to interact with other learners intellectually and is encouraged to be more self-directed. Learners should work in teams in a PPBL atmosphere, which necessitates the establishment of learning centres in which they assume leadership positions and duties, communicate both verbally and in writing, and accept responsibility for their learning and that of their teammates (cf. Nilson 2016). In this group, learners are given authentic learning opportunities to think critically and communicate creatively with content and group members. Doing so can maintain a supportive classroom where learners belong and have a secure place to connect to learning.

The importance of a constructive and encouraging classroom atmosphere

Considering what has been argued so far, it is clear that creating a safe and welcoming learning space is crucial if teachers are to help their learners develop a sense of independence and responsibility for their own learning, as well as a desire to actively engage in class, make meaningful contributions to group projects and ultimately succeed academically (Allen et al. 2021; Arslan 2018, 2021). Learners are more inclined to be motivated, inspired to learn and encouraged to achieve more profound knowledge when they feel respected and in charge of their learning (Allen et al. 2018). We believe that a constructive and encouraging classroom atmosphere can help learners think critically, solve authentic challenges, discover, understand, evaluate and implement learning resources while using subject matter knowledge, problem-solving skills and SDL skills to develop into persistent self-directed learners. Consequently, learners are not passive receivers of knowledge but are required to acquire the knowledge actively (Allen et al. 2018; Arslan 2018). Therefore, it can be assumed that the teaching context must permit learners to move beyond a passive role, be exposed to a constructive classroom atmosphere and cultivate a sense of self-direction in seeking knowledge. The teaching context must also motivate learners to practise higher-level critical thinking skills. Because this cognitive education approach builds on the learner's knowledge, the constructivist classroom atmosphere is centred on the learners' interests. It also emphasises interactive teaching and learning, where learners have conversations with teachers to assist them in creating knowledge.

From what we posed earlier, it can be deduced that a PPBL classroom atmosphere can impact learning. The learning experience in the PPBL environment should be filled with excitement, pleasure, satisfaction, achievement and joy. The classroom atmosphere mentioned above might encourage enjoyable, authentic learning. However, the emotions of fear, guilt and boredom demotivate learners in the classroom. In PPBL classrooms, where learners feel secure being themselves, they may use their life experiences to engage creatively with problems and learning material.

A sense of belonging as a precondition for ownership of learning

According to the Organisation for Economic Cooperation and Development (OECD 2019), one in three (1:3) learners lack a sense of belonging. Research (Allen et al. 2020, 2021; Arslan 2018) confirms the significance of embedding a constructive and positive classroom atmosphere to promote a sense of belonging which we also believe to be accurate within PPBL contexts. Safe and secure classroom settings play an important role in creating a sense of belonging (in any form of learning environment). Furthermore, a sense of belonging in PPBL classrooms must open the space for cooperation and connectedness (Allen et al. 2020; Joorst 2021). In this PPBL space of trusting connections, learners can identify with their classroom, problems and learning (Lester & Cross 2015; Reynolds et al. 2017). Allen et al. (2020) believe that a sense of belonging is where learners can feel individually recognised, accepted and part of the group. Research on the role of belonging in learning has constructed a view of how learners can optimally perform in a learning environment, be more self-directed in their learning, and how the role of belonging can improve learners' academic success and enable them to be more active in their learning (Allen et al. 2018; Martinez-Callaghan & Gill-Lacruz 2017). In addition, Ryan and Deci's self-determination theory (2000b) suggests that the grouping of constructive interactions endorses autonomy, understanding and competency, joined with constructive and encouraging classroom experiences that inspire learners to be concerned about school. We maintain that these aforementioned features mentioned should be embedded in a PPBL classroom atmosphere for learners to experience a sense of belonging.

A sense of belonging has steadily been perceived as more relevant in light of recent research that shows how a sense of belonging in a learning community is encouragingly associated with learner engagement, motivation, behaviour and performance (Maestas, Vaquera & Zehr 2017). Unfortunately, educational research has devoted far too little attention to understanding belonging, especially the effect of belonging within learning environments on learners' desire to take responsibility for their learning and be more self-directed.

As a result, this identified gap in the body of scholarship points to a need to comprehend the significance of belonging for acquiring ownership of one's learning (Du Toit-Brits 2022). Therefore, this chapter offers valuable insights into how a sense of belonging is a necessary constituent of PPBL, which itself is imperative for cultivating SDL skills. Maslow's (1962) research categorises love and belongingness at the centre of his order of needs. He further states that belonging to a learning community can increase learners' motivation and that this sense of belonging needs to be recognised as a necessary human component (Maslow 1970, 1987). So, this chapter harmonises Maslow's argument by signifying that a sense of belonging is essential for being a motivated, self-directed and self-determined learner. For this chapter, it should be emphasised that constructive and motivating learning experiences, such as pleasant learning, may stimulate a feeling of belonging and cognitive processing through intrinsic motivation. Learners may improve their self-efficacy, self-determination and self-direction, and satisfy their need for ownership and competence if they experience a sense of belonging. Du Toit-Brits (2022) believes that:

> [...] learners with intrinsic motivation, self-determination, and a sense of belonging are expected to employ SDL skills like critical thinking, problem-solving skills, autonomy, communication, taking ownership, taking responsibility, being accountable, and reflection. (p. 62)

Therefore, teachers must employ several active instructional strategies, such as PBL, cooperative learning (CL) and play-based learning, where the educational activities focus on cultivating SDL skills. Through these strategies, belonging can be embedded within these constructive and encouraging classrooms where teachers consider learners' learning needs (Allen et al. 2021). Thus, teachers must show thoughtfulness and care for their learners, which is essential for developing a sense of ownership and self-directedness in their classrooms.

Learners could experience a heightened sense of classroom belonging when they take ownership of and are responsible and accountable for their learning. When learners feel they belong to a classroom, it becomes 'their classroom' and 'their school'. Du Toit-Brits (2022) believes that it is essential for learners to belong within a learning environment, as this belonging gives them a sense of purpose and meaning. We argue that it is necessary that learners feel more empowered in the classroom through actively being a member of their classroom community, where they can feel that they are cared for and that their ideas are valued. Therefore, we believe that teachers should present learners with learning opportunities centred on a communal orientation that can support learners to know they are in a safe learning atmosphere where errors are acceptable. Subsequently, classrooms should be seen as learning environments inviting learners to feel at home. We propose that Teachers can cultivate learners' sense of acceptance, support, self-direction, joy and belonging actively implementing PPBL environments.

What is play-based learning, and why is it important?

Before motivating the importance of play-based learning (see ch. 2), we want to draw attention to some paradoxes between formal education and play-based learning. Formal educational settings tend to focus on and call for measurable outcomes and are, therefore, often product-oriented, whereas play-based learning is concerned with the *process of play* (Whitton 2018). Furthermore, Lynneth Solis et al. (2021) describe play as timeless and accessible, often messy and seemingly chaotic, as compared to school contexts that aspire to create order and where timetables frequently govern schools oppressively. In addition, play encourages risk-taking and provides opportunities for students to take responsibility for their learning instead of school environments that prioritise predictability and safety where the teacher sets the agenda (Lynneth Solis et al. 2021; Mardell, Lynneth Solis & Bray 2019). Despite these paradoxes, we advocate that play-based learning could provide valuable opportunities for teachers to challenge the status quo. By including playful activities in teaching and learning, learners could have many opportunities to develop autonomy, agency and self-direction and take ownership of their learning through fun, free and interactive activities.

In recent years, studies and discussions have increasingly focused on the value of play in education beyond early childhood education (ECE). Recent studies have drawn attention to the various motivations that can be made for including playful approaches in education (Baker, Le Courtois & Eberhart 2023; Leather, Harper & Obee 2021; Lynneth Solis et al. 2021). These studies focus on how play-based learning could support holistic development and foster social skills, motivation, creativity, problem-solving and coping skills through authentic teaching and learning experiences that are empowering and meaningful. Although ways that technology and innovative strategies could support play-based learning have recently featured prominently in innovative teaching approaches – such as escape rooms, game-building and digital games, it seems that there has also been a move back to more traditional games and general playful activities in education (Whitton 2018). This move could be ascribed to the fact that there has been an increased awareness of inequality between communities and insufficient resources in poorer schools. For example, in South Africa, many public schools serve learners who do not have sufficient Internet access or access to smart devices (cf. StatsSA 2020). Within these contexts, there is a need to find ways to utilise play-based learning approaches without relying on technological advances.

Defining play-based learning

When defining play-based learning or playful learning, we must acknowledge that how play-based learning is viewed is context specific. While play is often considered universal for children, adolescents and adults, the concepts and practices of how we play, whom we play with and when we play differ between contexts and across ages (Kangas et al. 2022; Lynneth Solis et al. 2021). Therefore, when designing play-based activities, teachers need to consider not only learner development when designing playful teaching and learning opportunities but also cultural values, socio-economic backgrounds, religion and belief systems, socio-political issues and ethnicity (Mardell et al. 2019). There are numerous conceptualisations and definitions for play in education. Many describe playful learning as fun, a joyful process that calls on the imagination and creates opportunities for laughing and joking. Play also develops learners to reach their full potential, fosters social skills and promotes holistic development (Barrett 2005; Leather et al. 2021; Poikela & Poikela 2005). Baker et al. (2023) further describe how playful learning occurs in contexts that are not only pleasurable but also flexible. They argue that it is within these active, fun contexts that learners can assign meaning to their learning.

Play-based learning is also closely associated with social constructivism and experiential learning (Leather et al. 2021). Play-based learning (Poikela & Poikela 2005) requires learners to be immersed in active learning experiences focused on and designed around genuine life problems and social issues. In addition, play requires an open mindset from learners whenever it offers them opportunities to engage in learning experiences that are discovery-based, creative and voluntary (Leather et al. 2021). We agree with Kangas et al. (2022, p. 6), who outline play as a process where learners do not learn 'through cognitive assignments but more through a way of being, living and perceiving the world'. Mardell et al. (2019, p. 5) further argue that 'schools [have to] exist for reasons beyond mere efficiency' and that taking risks should be an integral part of daily activities and learning. The LEGO® Foundation identifies five characteristics of play-based learning, namely that learning (1) happens through joyful activities, (2) requires active engagement, (3) is meaningful, (4) provides opportunities for social interaction and (5) calls for iterative thinking (experimentation) (LEGO® Foundation 2017).

Ultimately, we believe that play offers opportunities for joyful learning through which learners can develop their full potential, experience increased well-being and flourish. Unfortunately, it could be argued that play is a privilege (Whitton 2018) because it is not necessarily an experience that all learners have access to. However, we want to argue that playful learning is the right of learners of all ages because play is an inherent part of human nature.

Striving toward fostering 21st-century skills

Playful learning could be essential in fostering 21st-century skills because playful learning is equally social and cognitive and draws learners to focus on concrete and abstract ideas. Twenty-first-century skills include problem-solving, collaboration, language proficiency, critical thinking, creativity, decision-making and using digital technologies (Ananiadou & Claro 2009; Karatas & Arpaci 2021). Through playful approaches, learners can engage in teaching and learning experiences that consider various perspectives and ways of knowing, encourage social learning and link learning to real life, reflecting social constructivism principles. Through playful learning, learners have opportunities to explore various social issues, such as power relations and inequality, and solve complex problems through collaboration and critical reflection (Lombardi 2007). Learners who engage in play-based learning and PBL can build connections through group work, practice time management, and be innovative and creative when solving problems (Department of Basic Education [DBE] 2020). Playful learning further promotes self-management skills, awareness of others and a positive attitude (Leather et al. 2021). Lombardi (2007) argues that connection-building and creativity are essential 21st-century skills, as they foster life skills that will be important and valuable once learners enter the employment sector. If learners are to develop the skills needed to become successful and self-directed adults, teachers must create playful environments where learners will feel free and safe.

Creating safe, playful spaces

Before considering what safe, playful spaces look like, we must acknowledge that not all play is inherently associated with practical learning. Because of the social nature of play, educators must be aware that playful activities create opportunities for cruelty and discrimination as a result of power relations and societal inequality (Wood 2010) and inappropriate behaviour within diverse social contexts (Moon-Seo & Munsell 2022). If learners are exposed to discrimination, bullying or cruelty during play, it can inhibit their learning (Wood 2010). It could further be argued that pre-existing power relations and inequalities mean that we cannot create playful spaces that will indeed be safe for all learners (Whitton 2018). Similarly, teachers must realise that it is impossible to create playful learning experiences that will intrinsically motivate all learners and that they will not always be able to mediate failure. Therefore, learners need to find ways to design playful activities that are fair and that will encourage feelings of safety. Teachers must encourage ‘ongoing conversations’ (Whitton 2018, p. 4) between themselves and learners to foster motivation, navigate power relations and avoid inequality. To this end, safe, playful spaces must prioritise process over product and promote an ethic of care and respect (Baker et al. 2023).

If learners feel that their opinion is valued, they may be more open to engaging in PPBL activities, which could influence their intrinsic motivation. In addition, safe, playful spaces could provide environments where learners can engage in peaceful settings with opportunities and time to explore, collaborate and feel supported (Kangas et al. 2022). Yet, it is essential to note that engaging in fun activities does not automatically result in safe, enjoyable learning opportunities. Instead, through learner-centred approaches and an ethic of care, safe learning spaces will be constructed over time during reciprocal teaching and learning processes and by building relationships and trust within a fluid and evolving learning space (Mardell et al. 2019; Whitton 2018). The implication is that students will be fully active in the education and learning process by establishing objectives and collaboratively resolving issues within dynamic and ever-changing learning settings. Ultimately, teachers must strive to create safe, playful learning environments that are accessible, where learners are relaxed, and that encapsulate social justice, foster empathy, offer positive challenges and foster trusting relationships (Lynneth Solis et al. 2021; Mardell et al. 2019; Whitton 2018) resembling a democratic teacher rather than an autocratic one.

Authentic, meaningful learning through play

Through PPBL, learners could create meaning from interactive, social learning experiences that encourage creativity, divergent thinking and problem-solving (Wood 2009). Suppose teachers want to design authentic and meaningful play-based learning activities. In that case, they must provide learners with opportunities to engage in experiential, problem-based, fun learning activities that relate to their real lives and foster connection (Kangas et al. 2017). Playful learning will be authentic and meaningful if learners regard such learning as essential and if they are interested and invested in their learning. Accordingly, it is paramount that learners are aware of the real-life value of playful learning activities. Learners must also feel inspired and motivated to fully engage in their learning activities (Lynneth Solis et al. 2021; Poikela & Poikela 2005) through curious discovery and discussing real-world issues (Baker et al. 2023).

Authentic playful learning should lead to increased learner engagement and foster creativity and collaboration. Authentic playful learning should also provide safe spaces where learners can imagine and explore various ideas and perspectives to solve relevant problems through questioning (Lynneth Solis et al. 2021) and iterative thinking, which involves a logical and systematic thinking process (Mardell et al. 2019). Lombardi (2007) identifies critical elements that define authentic learning experiences. She explains how authentic learning experiences must have real-life value and that learners must solve challenging and ill-defined problems. Like Lynneth Solis et al. (2021), Lombardi (2007) also explains that learners must engage with diverse perspectives through collaboration and critical reflection.

When designing authentic and meaningful PPBL activities, teachers must consider how their assessment strategies will reflect real-world evaluation processes. Doing so implies that, rather than being merely summative, assessment strategies need to accommodate different interpretations of outcomes and numerous, varied solutions to problems (Lombardi 2007). We also believe that the nature of relationships is central to how learners experience authentic playful activities. Relationships are not only integral to meaningful teaching and learning experiences. Instead, fostering meaningful connections is also an important life skill (Kangas et al. 2022; Lombardi 2007). We ultimately agree with Lombardi (2007) that '[a]uthentic learning may be more important than ever in a rapidly changing world, where the half-life of information is short, and individuals can expect to progress through multiple careers':

> Although foundational skills (reading, writing, mathematics, history, language) remain essential, a more complex set of competencies are required today. These go beyond being technically competent to being able to get things done, demonstrate ethics and integrity, and work well with others. According to employers, the most important skills in new hires include teamwork, critical thinking […], […] organising information, and […] creativity. (p. 10)

We believe that the skills associated with problem-solving, questioning, iterative thinking and connection promote SDL, as they prepare learners with valuable life competencies that are also the basis for vocational readiness.

Playful problem-based learning supports self-directed learning

We argue that PPBL is closely associated with SDL and self-determination theory, as it requires learners to manage their learning through autonomy, relatedness, motivation, problem-solving, critical reflection and self-actualisation (Karatas & Arpaci 2021; Loeng 2020; Ryan et al. 2021). We concur with Lynneth Solis et al. (2021, p. 6), who argue that contextually relevant 'playful learning provides opportunities for [learners] to become confident, self-directed learners […] who can participate in a democratic society and engage in the 21st-century economy'. We further argue that PPBL is a means through which learners can authentically develop the skills associated with SDL by being empowered, being motivated, developing agency, developing self-actualisation, being creative, solving problems, experiencing a sense of belonging and developing coping skills when they deal with various challenges.

Being empowered

When we refer to how learners are empowered through PPBL, we keep in mind how playful learning supports learners to make decisions, set their own goals and take ownership of their learning (Karatas & Arpaci 2021; Lynneth Solis et al. 2021), which are essential skills associated with SDL (also see ch. 1). Lynneth Solis et al. (2021) describe empowered learning as learning that fosters agency, motivates independence, creates a sense of belonging and allows learners to be free, develop confidence and be proud of their achievements. Playful learning spaces provide learners with opportunities to develop and practice independence through an iterative, collaborative process which in turn empowers them (Husbye et al. 2012). Playful learning further empowers learners by encouraging them to take risks within safe spaces, co-construct rules, express their opinions, engage in discussions and debates, and, importantly, also learn that there is no shame in asking for help (Lynneth Solis et al. 2021). When learners feel empowered, they can gain confidence in their ability to succeed, influencing their motivation, agency and self-directedness in learning.

Being motivated

One of the essential skills that could be developed through authentic PPBL is intrinsic *motivation*. Motivation is also an essential aspect of autonomy (Ryan et al. 2021), as it influences how people behave, how and why they engage in certain activities, and how they make decisions and interact socially. Through motivation (intrinsic and extrinsic), learners should be encouraged to take responsibility and control their learning, become autonomous learners and achieve meaningful learning outcomes (Garrison 1997). Although learners could also experience extrinsic motivation based on reward and academic success when engaging in playful activities, we argue that intrinsic motivation is more critical and effective considering long-term needs for self-directedness and well-being. For example, if learners believe that PPBL activities are valuable, and if such learning occurs within safe spaces, learners could experience a heightened sense of intrinsic motivation to engage in playful learning activities (Whitton 2018). Intrinsic motivation will encourage learners to be more self-directed, take risks and experiment in conditions where they feel free and safe and that the learning has personal meaning for them (Kangas et al. 2017; Leather et al. 2021; Whitton 2018).

On the contrary, we hold that if learners only experience extrinsic motivation during PPBL activities, it could lead to resentment and disinterest in continued engagement with this type of learning. This notion is also supported by the work of Ryan and Deci (2000a), who wrote that extrinsic motivation could be associated with resistance and disinterest if learners participate in actions without intention. If we suppose that learners are willing to engage in such learning activities for fun and personal gain, it could lead to associating the activities with a feeling of inherent satisfaction. Consequently, learners could be more likely to develop agency (Baker et al. 2023) and flourish as self-directed learners.

Developing agency

Learners' agency is developed when they have opportunities to take control of their learning and willingly participate while feeling intrinsically motivated (Baker et al. 2023; Ryan et al. 2021). We argue that PPBL activities provide valuable opportunities for learners to take control of their learning and that these activities will promote intrinsic motivation and self-direction. When learners have agency, they are committed to their learning and can make decisions independently. Responsibility is an essential aspect of agency, as learners also need to consider how their decisions and choices will influence their course of action in the future. Through agency, learners also develop new, creative ways of doing things. This is a vital skill for coping with challenges, solving problems and being more self-directed (Kangas et al. 2022). Agency, therefore, also influences learners' ability to self-regulate when they experience pressure or face challenges during playful learning because they must continuously reflect on and evaluate their decisions when faced with new problems (Baker et al. 2023). This ability to deal with and overcome challenges could, in turn, foster determination and resilience and support the development of skills that are associated with self-actualisation and SDL.

Developing self-actualisation

Motivation and agency are essential skills to develop if learners are to experience self-actualisation and reach their full potential (Loeng 2020). One of the key benefits of playful learning beyond early childhood is that it contributes to personal growth and self-actualisation (Leather et al. 2021). Through engagement in PPBL, learners can develop the ability to control their emotions, deal with conflict, act with care and compassion, and accept diverse opinions. Self-regulation is an essential aspect of self-actualisation. It can be developed through playful learning because playful spaces require learners to adapt their behaviours and control their emotions while working collaboratively to explore and engage with authentic problems (Baker et al. 2023). Henricks (2014) writes about how play cultivates selfhood, which relates to how people understand themselves, their experiences, abilities and roles within communities and society (Leather et al. 2021). When learners engage in playful learning, they learn about themselves and others within specific and diverse contexts through agency, motivation, exploration, questioning, collaboration and problem-solving. Within these playful contexts, learners also explore their abilities and are confronted with diverse beliefs and ways of knowing. They are further required to negotiate their beliefs with the beliefs of others, which supports self-realisation (Henricks 2014; Leather et al. 2021). We believe that self-realisation is a stepping-stone to self-actualisation and self-directedness and that motivation and agency are integral processes that must take place if learners are to reach their full potential.

Developing creativity and problem-solving skills through hard fun

As previously stated, creativity and problem-solving are essential 21st-century skills that help to promote SDL (Loeng 2020; Lynneth Solis et al. 2021; Ryan & Deci 2000b). Creativity is also an essential part of PBL and central to notions of play-based learning (Poikela & Poikela 2005). When learners have opportunities to engage in playful learning within safe spaces, they have to be creative when faced with problems (Leather et al. 2021) and engage in activities where they individually and collaboratively explore various solutions to solve problems and overcome challenges (Andreopoulou & Moustakas 2019).

Poikela and Poikela (2005) write about how playful learning is associated with 'hard fun' (p. 162) and argue that problem-solving and facing challenges are closely associated with playful learning and PBL. The term 'hard fun' was initially coined by Papert (1996), who argued that learners have fun learning *because* the learning activities are difficult, even though it is challenging. According to Poikela and Poikela (2005), hard fun, therefore, defines learning as fun and challenging simultaneously. When learners learn through hard fun, they can challenge themselves while also experiencing 'enjoyment, laughter, freedom, creativity and energy' (Poikela & Poikela 2005, p. 162). They explain that learning is only meaningful because it is hard and learners tend only to enjoy learning if it presents challenges. Ultimately, failure is a critical factor in hard fun, and authentic PPBL can help to foster resilience through iterative engagement (Whitton 2018). We believe that failure in playful learning (games), for instance, allows the learner to try again without feeling ashamed. Playful problem-based learning is meaningful because it challenges learners to find innovative solutions to problems and engage with new ways of knowing. When writing about how PPBL supports joyful learning and promotes SDL and flourishing, we specifically have hard fun in mind rather than seemingly superficial and frivolous play (Leather et al. 2021; Poikela & Poikela 2005). When teachers design PPBL activities, they must create spaces for learners to feel free and safe, where they are actively engaged and immersed in learning, can collaborate with peers, have fun, can be silly and laugh, can be creative and innovative, and are ultimately challenged (Poikela & Poikela 2005). Learners need opportunities to engage in playful spaces where they are motivated to exercise their agency, foster relationships, learn to self-direct, persevere, and solve problems to reach self-actualisation and flourish.

Playful problem-based learning promotes well-being

We believe that the characteristics of agency, choice-making, goal-setting and iterative thinking associated with PPBL also align with hope theory (Snyder 2002). Intrinsic motivation similarly plays a role in hope theory, problem-solving abilities, optimism and self-efficacy. Hope theory describes how individuals strive toward attaining their goals through agency, emotional regulation, and thinking pathways that describe adaptive thinking and critical reasoning. In turn, adaptive thinking and critical reasoning are skills that enable individuals to cope with and overcome the various challenges that influence and determine agency.

In addition, by prioritising obstacles in learning, hard fun is also concerned with laughter, independence and satisfaction (Poikela & Poikela 2005). Consequently, playful learning environments encourage joyful learning and well-being (Andreopoulou & Moustakas 2019). We argue that PPBL is also enjoyable because it involves spaces where learners are free to explore and be creative and can experience joy, build relationships and feel good (Leather et al. 2021; Poikela & Poikela 2005). Lynneth Solis et al. (2021) describe the joy experienced in playful learning as teaching and learning experiences that promote excitement, anticipation, happiness, fun and togetherness. Joyful, playful activities also offer a sense of comfort despite being challenging. Activities that foster joyful learning are further associated with an element of surprise, laughter, silliness, and shared creations and discoveries. We believe that notions of silliness, laughter and joking promote happiness and positive emotions and are paramount to using PPBL to enhance well-being. Playfulness and positive emotions, in turn, promote creativity and motivation, which are critical aspects associated with playfulness and PBL (Leather et al. 2021; Poikela & Poikela 2005).

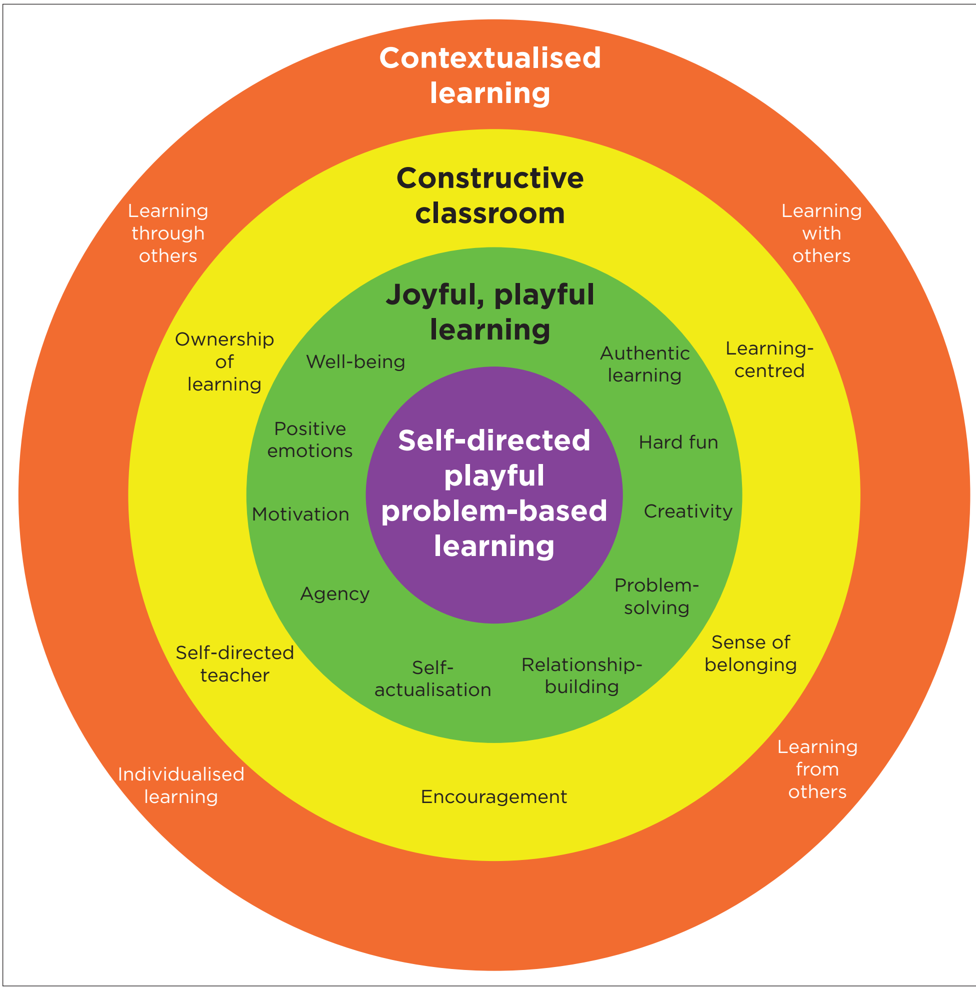
Positive emotion (P) is a central element in the PERMA (positive emotions, engagement, positive relationships, meaning and achievement/accomplishment) well-being theory (Seligman 2011, 2018), along with *engagement* (E), *relationships* (R), *meaning* (M) and *achievement* (A). However, as discussed in this chapter, engagement, connection, belonging and relationships, meaning and authenticity, achievement, success and self-actualisation are all central components of PPBL as well (Andreopoulou & Moustakas 2019; Baker et al. 2023; Barrett 2005;

Leather et al. 2021; Poikela & Poikela 2005). This latter notion supports our argument that joyful PPBL could also enhance learners' SDL skills and well-being.

A conceptual framework for self-directed playful problem-based learning to promote joyful learning

As the preamble to the framework proposed in this chapter, we would like to highlight characteristics that underpin authentic and self-directed PPBL that emerged from our study. Social-constructivist principles inform these characteristics and include that learning must occur within safe spaces, be designed with learner needs in mind, have real-life value, and provide opportunities for learners to build relationships and experience a sense of belonging. In addition, engagement in self-directed PPBL activities will enable learners to become intrinsically motivated and self-disciplined, think about and reflect on their thinking (metacognitive skills) and have high levels of self-determination. Moreover, within these PPBL contexts, learners can adjust their learning, monitor their progress, and are intrinsically motivated to identify, set and pursue their self-determined goals and objectives. Furthermore, PPBL activities support learners' ability to self-assess, engage emotionally in the learning process and persevere.

One of the aims of this chapter is to generate a conceptual framework (Figure 4.1) for self-directed PPBL grounded in principles associated with SDL to promote joyful learning. The framework was developed through thematic analysis (Clarke, Braun & Hayfield 2015) and is informed by the scholarly literature discussed in this chapter. The framework holds that for self-directed PPBL to occur, learning must be contextualised in that learners must have opportunities to learn in a self-directed manner through, with and from others and to actively engage in teaching and learning activities that meet their individual needs and abilities. Furthermore, teachers must create constructive SDL classrooms and apply learner-centred teaching and learning strategies. Within these constructive classrooms, learners have SDL opportunities to experience a sense of belonging while being encouraged by self-directed teachers who motivate learners to take ownership of their learning. Finally, we argue that self-directed PPBL results from playful activities where learners experience joy while engaging in self-directed PPBL activities that promote authentic learning and hard (challenging) fun. Self-directed PPBL further promotes creative problem-solving, relationship building, self-actualisation, agency, intrinsic and extrinsic motivation, positive emotions and, ultimately, well-being.



Source: Authors' own work.

FIGURE 4.1: A conceptual framework for self-directed playful problem-based learning to promote joyful learning.

Recommendations for transformed teaching and learning practices

As this chapter concludes, we propose suggestions for transformed teaching and learning practices. For joyful learning to occur, we recommend cultivating safe and secure learning environments and inculcating a sense of community in the learning settings. Moreover, we recommend that independent learning should be encouraged in learning communities (learning environments) while mounting necessary skills, thereby developing autonomous, open-minded and self-directed 'owners of learning' who can recognise their own learning needs. We also suggest designing a classroom where learners discover their identities, learning styles, interests and motivations for acquiring new information. Learners need to pursue their learning with passing and curiosity and to do so while the necessary space for making mistakes is in place. That said, such a space will allow learners to make mistakes without consequences as part of the learning process. Failure to create such an SDL environment can cripple their ability to take on new learning endeavours. Suppose learners have self-directed PPBL opportunities to experience failure within safe teaching and learning spaces. In that case, they develop skills that foster innovative, creative problem-solving skills essential for them to overcome challenges and develop resilience.

Further, we recommend encouraging an attitude of curiosity, so that learners can feel free to explore learning. Learners should be given a voice in their classrooms so that their classrooms can become platforms where they feel empowered. Therefore, we recommend that learning activities be of such a nature that they support learners to develop their own voices, which we regard as much more important than extrinsic motivation. Learners should also be offered opportunities to take responsibility for their learning and set their own goals. Doing so can assist learners in discovering themselves in their learning activities and building trust and confidence in their abilities through learning.

A constructive and encouraging classroom atmosphere where self-directed PPBL strategies are utilised must show learners how to overcome fear and disappointment. Therefore, we argue that collaboration and building meaningful relationships are key preconditions for learners to experience meaningful learning. Collaboration and building meaningful relationships are integral to personal development, as relationships promote the development of SDL skills associated with self-actualisation. Through self-directed PPBL and joyful teaching and learning activities, we believe learners can experience hope and improved well-being.

■ Conclusion

In conclusion, this chapter contributes to the body of knowledge by expanding insights into the theoretical underpinnings for self-directed PPBL as a pedagogical choice for implementing meaningful education. We argue that self-directed PPBL experiences that are hard and joyful could ultimately be transformative. The framework suggested in this chapter indicates that whenever learners have the opportunities to engage in authentic teaching and learning experiences, where they face real-life problems and engage with multiple ways of knowing, they can, as a consequence, experience personal and social transformation. By applying the self-directed PPBL framework, teachers can foster teaching and learning environments that promote an ethic of care, compassion and a sense of belonging. Self-directed PPBL could further be transformative by creating environments where learners can create novel meanings when they explore and manipulate various resources and change or adapt their behaviour based on social negotiation and interaction. Within these contexts, learners can challenge societal inequality and disrupt established norms associated with subjugation, otherness and exclusion. Through these co-constructed, safe, joyful and self-directed PPBL experiences, learners can feel valued, cared for and belong, enabling them to reach their full potential and flourish. Thus, learners who discover the joy of learning can make a signification contribution to their communities.

Chapter 5

Mathematics education students' development of computational thinking through game-based tasks

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Abstract

There is a worldwide emphasis on computational thinking (CT) as an essential skill for the Fourth Industrial Revolution (4IR). The notion of CT involves various thought processes associated with solving real-world problems based on the attributes of computer science. This chapter deals with the active involvement of mathematics students in game-based tasks with the aim of developing CT skills. A general qualitative research approach was followed. One cohort of 61 second-year Bachelor of Education (BEd) students registered for the Intermediate Phase (Intersen) module in mathematics and collaborated in groups of five–six members. They had to

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design a game based on a mathematical topic to introduce students to the topic. This was followed by activities where they had to solve mathematics problems using the visual *Scratch* (n.d.)[2] programming environment. Data collection comprised two coding tasks. This was followed by the completion of individual reflective questions. It was evident from the qualitative findings that students developed some CT abilities. We also posed some recommendations for teacher education.

Introduction

An increasing focus on digital competencies requires students to be prepared for the challenges ahead, and specifically to develop skills for the 4IR. One such competence is the notion of CT, as suggested in the seminal work of Jeanette Wing (2006).

Computational thinking emphasises approaches and thought processes associated with solving real-world problems based on computer science attributes. Relkin, De Ruiter and Bers (2021, p. 2) refer to CT as 'a set of heuristic reasoning skills that can be categorised into discrete sub-domains applicable to problem-solving in computer science and other disciplines'. Computational thinking as a cross-disciplinary skill involves computer science fundamentals, requires high-level thinking and prioritises social interaction in authentic tasks to solve intriguing real-world problems (Hava & Ünlü 2021; Korkmaz, Çakir & Özden 2017). Several scholars assign the following core attributes to CT, namely the ability to:

- simplify complex problems (abstraction)
- use stepwise (particular steps) and algorithmic thinking
- break down a problem into convenient and manageable elements (decomposition)
- identify similarities and differences between patterns (pattern recognition) to make sense thereof and solve such a problem (Grover & Pea 2018; Wing 2006).

In other words, CT is a way of conceptualising and solving real-world problems typical to humankind (Hsu, Chang & Hung 2018).

The acquisition of CT is of importance in education. Umutlu (2021, p. 1) states, 'CT should be one of the skills emphasised in 21st-century classes as students [...] are needed to solve contemporary complex problems'. Czerkawski and Lyman (2015) explored CT in higher education (HE) and referred to its application in cross-disciplinary fields, such as physics, statistics, bioinformatics and archaeology. Moreover, Hsu et al. (2018)

2. https://scratch.mit.edu/about.

investigated how CT should be taught and learnt and emphasised that the core of implementing CT is knowledgeable teachers who have to scaffold learners in this regard. However, studies suggest that pre-service teachers require extended exposure to develop a profound understanding of CT and enhance efficiency (Butler & Leahy 2021). It is therefore essential to prepare pre-service students to develop CT skills themselves to support learners in addressing open-ended problems. Computational thinking can also be implemented as part of pedagogy of play (PoP) (see ch. 2) and game-based tasks where the emphasis is on learner–student engagement in playful activities and collaborative problem-solving to develop distinctive future skills (Czerkawski & Lyman 2015; Tsarava, Moeller & Ninaus 2018).

To give a more nuanced understanding of CT in teacher education, this chapter aims to report how mathematics students developed CT in game-based tasks. The following research questions, therefore, guided this research study:

1. Which opportunities are involved in game-based tasks to support student collaboration?
2. How do mathematics students develop CT in game-based tasks?
3. Which affordances does CT provide towards students' self-directed learning (SDL)?

Context and related work

Some aspects related to CT are outlined in this section.

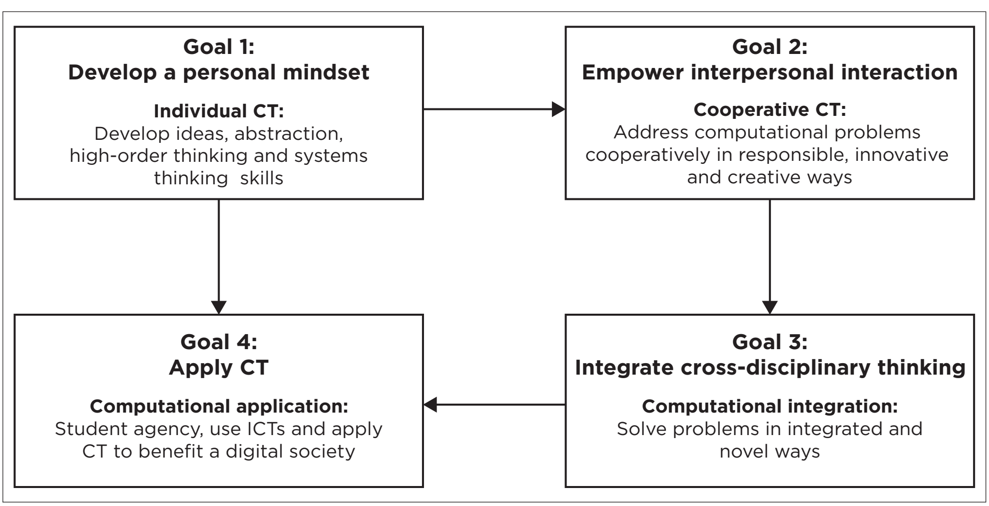
Constructionist view

Computational thinking is based on the constructionist view, where learning is promoted when learners are actively involved in knowledge construction (Butler & Leahy 2021). Seymour Papert developed the constructionist approach, which is grounded in the tenet that knowledge is constructed where learners engage in social interaction (Papert 1980). Papert (1980, p. 4) asserts that programmable objects will influence the lives of learners in such a way that they develop ideas, 'form new relationships with knowledge' and construct new meaning. Papert developed the LOGO graphical environment – using commands that control a metaphoric turtle – to facilitate people in learning programming and playing games where strategic thinking is required (Benelhardi et al.) (see ch. 7). Papert (1980, p. 21) also emphasises that such engagement can provide for learning that becomes 'active and self-directed'.

Development of computational thinking

Concerning problems related to the computer science domain, Czerkawski and Lyman (2015, p. 58) argue that some are 'computable' while others are 'non-computable' (e.g. infinite execution). Yildiz Durak (2020) highlights the importance of high-order thinking, detailed knowledge and an effective coding process to address such problems. As far as CT is concerned, it involves a particular way of thinking based on computer science principles regarding approaching and solving a problem with no obvious solution. The key aspects of CT involve abstractions of complex problems, algorithmic thinking, as well as the identification of similarities between problems (pattern matching) and the breaking down of an intricate problem into reducible parts (Grover & Pea 2018; Wing 2006). Wing (2006, pp. 2, 3) also refers to essential abilities, such as 'reformulation [...] recursion [...] reduction, embedding, transformation, or simulation [and] backtracking' when addressing open-ended problems. Computational thinking is therefore considered a specific way of approaching and solving a real-world problem by applying powerful strategies associated with computer science. Based on what CT entails (Wing 2006, pp. 1–4), it is worth considering the following integrated goals as displayed in Figure 5.1:

- **Goal 1:** To *develop a personal mindset* comprising essential and fundamental thinking skills (e.g. concepts, ideas, abstractions, reasoning, judgement, estimation and reformulation, high-order thinking and



Source: Author's own work.
Key: CT, computational thinking; ICTs, information and communication technologies.

FIGURE 5.1: Integrated goals of computational thinking.

systems thinking, modelling, reflective thinking, correction, reliability and optimisation) on how to solve puzzling real-world problems by applying the principles of computer science.
- **Goal 2:** To *prioritise interpersonal and social interaction* and empower people to address computational problems jointly in responsible, innovative and creative ways.
- **Goal 3:** To *integrate and complement cross-disciplinary thinking* with the aim of solving problems in novel ways and developing a profound understanding thereof.
- **Goal 4:** To *apply such thinking on different levels*, platforms, virtual worlds, repositories, hybrid spaces and problem-based environments to benefit a digital society.

The goals mentioned here are also aligned with the competencies referred to by Pala and Mıhcı Türker (2021), as the authors concur with the International Society for Technology in Education (ISTE) in terms of empowering learning, constructing knowledge, being innovative and communicating inspired ideas, being a digital citizen, thinking computationally and being able to work together with other people.

The question follows whether CT can be learnt and, if so, which skills and supportive strategies are essential for meaningful learning? Scholars mention there is uncertainty about developing CT skills in the classroom and employing supportive thinking strategies (Pala & Mıhcı Türker 2021). Umutlu (2021) mentions that several attempts have been made to integrate CT into the classroom. Unfortunately, teachers do not necessarily have the necessary knowledge about computer science or the relevant professional support and pedagogical knowledge, and they experience a lack of collaboration with teachers who are knowledgeable about computer science (Umutlu 2021).

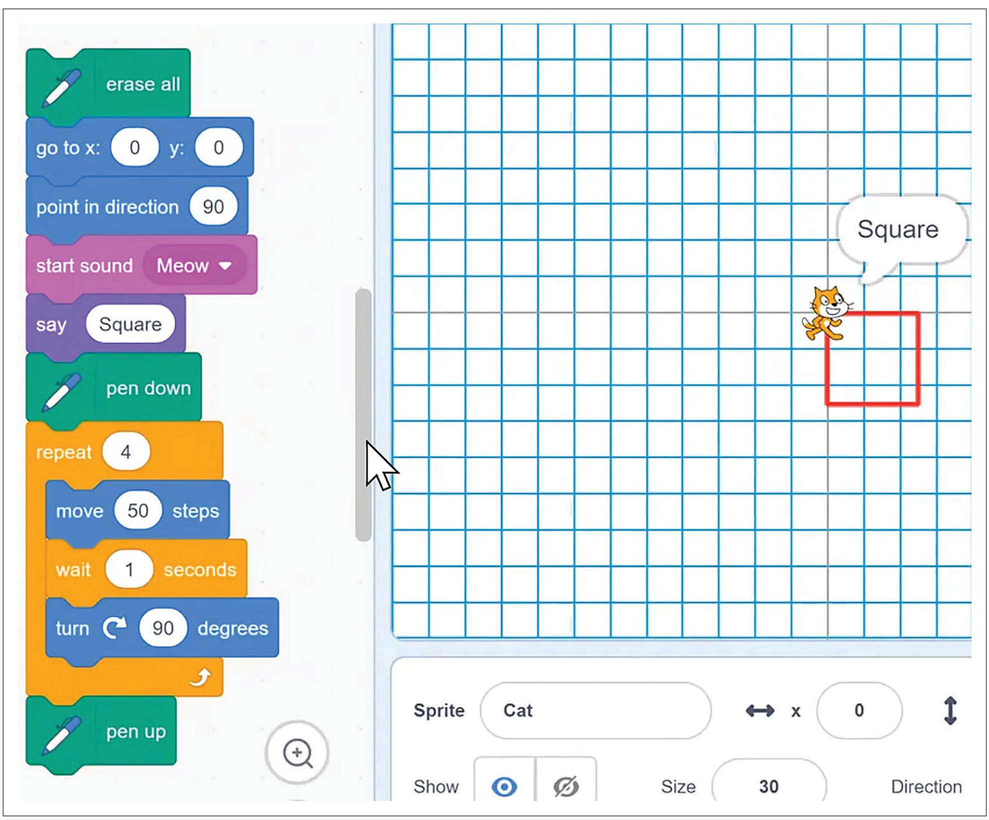
Computational thinking is a challenge for some teachers. For example, mathematics teachers are used to solving problems in a certain way by applying a formula. Such an approach can limit their thinking and reasoning when solving real-world problems (Hsu et al. 2018). Mathematics requires several ways of thinking, and it enables people to make sense of the world, investigate phenomena, make deductions, prove certain properties, gather data and make measurements and implement mathematical models (Schoenfeld 2016). Nevertheless, Wing (2006, p. 3) emphasises that CT involves the ability to 'think computationally, not just mathematically'. Consequently, CT is a crucial competence in various domains, and teachers have to plan and provide opportunities for the learning and application thereof (Hsu et al. 2018). Several scholars highlight using block-based tools and teaching–learning strategies to assist in developing CT skills (Brennan & Resnick 2012; Hsu et al. 2018; Relkin et al. 2021; Umutlu 2021).

Block-based tools to develop computational thinking

Whether tools are digital (software) or physical (tangible objects), they can be used for meaningful learning and knowledge construction (Dhakulkar & Olivier 2021). Some examples of block-based tools and free software that may assist in the development of CT are *Scratch* (Relkin et al. 2021) and *micro:bit* (Shahin et al. 2022).

Scratch programming environment and repository

Scratch is an online visual programming environment that can be downloaded freely. The integrated development environment (IDE) comprises visually coloured block-based codes (the block palette on the left in Figure 5.2) that are used to give instructions (scripts) and



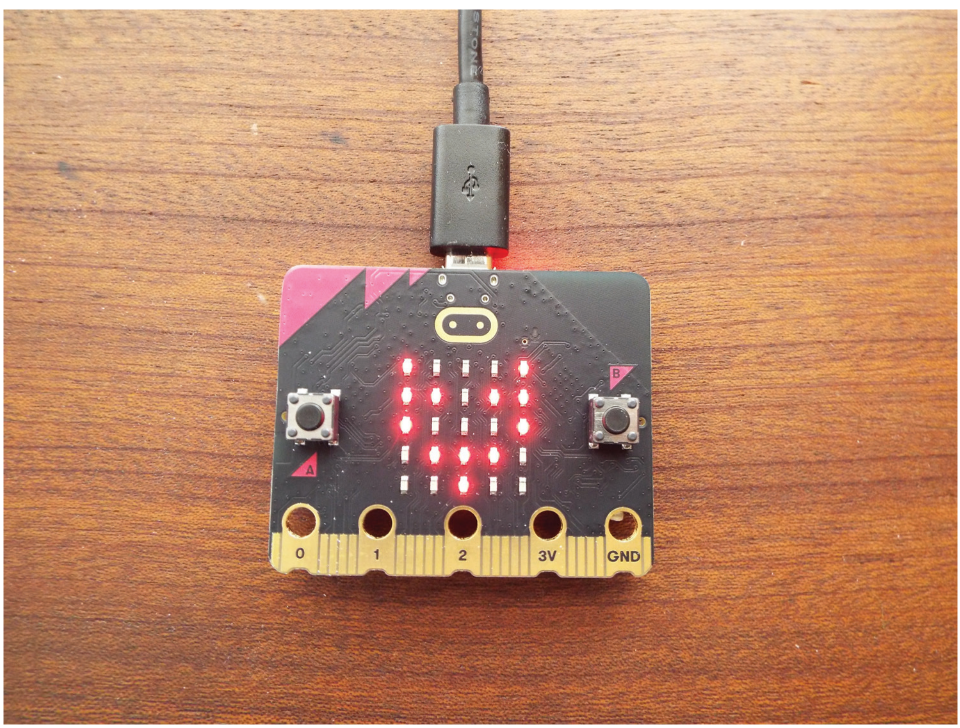
Source: Screenshot of the output from *Scratch* (MIT Media Lab version 3.0) taken by Marietjie Havenga, 12 April 2023, published with permission from Marietjie Havenga.

FIGURE 5.2: The output is displayed in the *Scratch* programming environment.

control sprites. A sprite (the cat on the right in Figure 5.2) is an object that executes the programming instructions or codes. Sprites can move and interact with one another. This IDE enables students to create their own animations and games, and additional functionality involves an introduction to the foundations of electronics.

☐ BBC *micro:bit*

The *micro:bit* was developed in the United Kingdom (UK) to provide opportunities for learners to become involved in programming and basic electronics. The *micro:bit* is a small computer (smaller than a credit card) that comprises two buttons, sensors and a light-emitting diode (LED) display for output. Programming output can be done with the IDE simulation (Figure 5.3) (using *Microsoft MakeCode* – a free online platform) or on the small physical *micro:bit* board (Figure 5.3).



Source: Photograph taken by Marietjie Havenga, 22 November 2022, location unknown, published with permission from Marietjie Havenga.

FIGURE 5.3: Program output is displayed on *micro:bit*.

Teaching–learning strategies to promote computational thinking

Diversified teaching–learning strategies can be used to assist in the development of CT skills. Hsu et al. (2018) mention student-centred strategies relevant to CT: Problem-based learning (PBL), cooperative learning (CL), game-based learning (GBL), project-based learning, design-based learning, storytelling, scaffolding and embodied learning. Such strategies pave the way for group work and social interaction while solving a problem. Hadad et al. (2021) also mention prominent strategies, such as tinkering and debugging, experiential learning and collaborative learning for developing CT skills. Although PBL, based on a challenge, directs students' activities, we employed GBL to provide instances where mathematics students could develop CT skills.

Game-based learning

The teaching and learning of CT can be supported by employing play-based strategies and GBL (see ch. 2). Czerkawski and Lyman (2015, p. 60) emphasise that GBL should be considered an 'effective strategy' to develop essential CT skills because it supports understanding programming aspects and reasoning in a joyful and visual environment. Tsarava et al. (2018) implemented GBL focusing on the key concepts of CT by employing unplugged board games. They emphasise that GBL motivates learners to interact with each other and aim to develop programming skills, such as iteration and patterns; mathematics skills, such as spatial orientation and angular degrees; as well as skills related both to programming and mathematics (e.g. variables and operators) (Tsarava et al. 2018). Turchi, Fogli and Malizia (2019) focused on group collaboration and students' involvement in GBL with the aim of improving CT abilities. Their results indicate that games and a playful learning environment are conducive to developing students' CT skills using group activities.

Computational thinking and self-directed learning

Development of CT requires abilities such as reflective thinking and SDL (Threekunprapa & Yasri 2020). Students must select relevant resources, develop fundamental skills instead of rote learning, evaluate possible solutions and develop a deep understanding (Wing 2006). The essence of SDL is the ability of individuals to be independent and responsible, manage their own learning processes, make decisions about how to approach and solve problems and be persistent in solving them. Threekunprapa and Yasri (2020) argue that passive learning and remembering will demotivate learners, whereas active learning and task engagement motivate learners. They propose a 3S SDL method to promote the development of CT skills in secondary learners, namely self-checking (in pairs), self-debugging (in pairs) and scaffolding (teacher) (Threekunprapa & Yasri 2020, p. 1025). Hadad et al. (2021) studied teachers' professional development in an online coding and robotics course – using *Scratch* – with the aim of developing their CT skills. They used synchronous sessions and asynchronous activities during the coronavirus disease 2019 (COVID-19) pandemic lockdown restrictions. To enhance independent and responsible learning, Hadad et al. (2021, p. 786) highlight 'teachers must experience SDL themselves' to develop CT competencies. Yildiz Durak (2020) studied secondary school learners' engagement, reflective thinking and CT when doing programming tasks. The findings indicate that *Scratch* provided for developing SDL abilities and increased learners' motivation. Consequently, SDL abilities, such as persistence, initiative and responsibility in learning, curiosity and the development of a plan (Guglielmino 2013), are valuable and supportive in promoting meaningful CT skills.

Research methodology

Although the current research forms part of a project that employed a mixed-method approach, this chapter is concerned with the phase that used a qualitative methodology. The qualitative phase involved mathematics students' interaction and collaboration, their experiences and skill development in game-based tasks.

Participants and research ethics

In total, 61 second-year students registered for a module in mathematics participated. They were Afrikaans- and English-speaking residential students who were required to collaborate online because of the COVID-19 pandemic. The co-author, who was also the lecturer, randomly assigned the students in groups at the beginning of the semester. There were twelve groups with about five–six members per group. Each group chose a leader who had the following responsibilities:

- To ensure that all members actively participate and stay on track.
- To schedule the Microsoft (MS) Teams or Zoom meetings.
- To communicate with members on their WhatsApp group.
- To complete and submit the group assignment before the due date.

Ethical clearance was obtained from the North-West University's (NWU) Faculty of Education, South Africa. The research only involved willing participants who provided informed consent.

Context and student activities

Participants had no previous exposure to the *Scratch* programming environment, coding or CT. As part of the preparation, students therefore had to read an article about CT and had to watch three YouTube videos on the *Scratch* visual programming environment as well as some videos about teaching learners and students how to code. The purpose of the assignment was to integrate CT as part of students' teaching–learning practices by linking it with the Department of Basic Education's (DBE) *Curriculum and Assessment Policy Statement* (CAPS) for Intermediate Phase (Intersen) mathematics. The assignment comprised the following activities:

1. Students had to compile a game based on a specific mathematics topic (see details, Activity 1).
2. Students had to do two programming tasks (A and B) where the *Scratch* sprite had to sketch certain geometric shapes according to the execution of the block-based code.
3. An MS Teams meeting had to be held to reflect on their thought processes and optimise the coding.
4. An MS PowerPoint presentation had to be compiled by the group regarding their roles (number 2), an overview of their programming tasks and suggestions to improve the assignment.
5. Individual completion of reflective questions on Google Forms.

Activity 1: Mathematics and computational thinking

Students had to create a cost-effective activity for Grades 4–6 learners to link CT with a specific mathematics topic. For example, students had to specify which aspects or features of CT they had used and why and how their activity was linked to a specific mathematics topic. They also had to explain how they would provide learners with opportunities to develop such thinking. This activity aimed to develop a better number sense and employ strategies to formulate and solve the problem. The groups created a variety of activities, such as movement and position, creating patterns with sticks and bottle tops, multiplying whole numbers, applying pattern recognition using dominoes and solving algebraic equations according to the order of operations.

The 'Among Us' tour (Group 04, 29 November 2021) was an example of GBL, where CT was applied. Students compiled the activity involving knowledge of the Grade 6 mathematics CAPS curriculum (Term 4), which deals with space and shapes (geometry), position and movement. Graphs and calculations are also introduced. The compiled activity is as follows: Learners work in groups and receive a copy of a map (board with a floor plan), a route-recording sheet and an image of an object (person).

The object must move around the board, start at a certain position (entrance), visit all the other positions (rooms) only once and finally return to the entrance, completing the route in no more than twelve moves. Each move should be recorded on the recording sheet. Learners must be actively involved, apply CT and reflective and critical thinking to determine the best route, and then evaluate the solution.

Coding tasks using *Scratch*: Task A

The first coding task introduced students to *Scratch* and entailed drawing the decagram (10-point star polygon) using the block-based codes. They had to use, among others, the repeat, move and turn instructions to create the polygon. To achieve this, the students had to think about and determine the exterior angle to ensure the polygon was drawn correctly. Furthermore, they had to copy five Scratch block code images with matching *Scratch* output (program execution) sequentially to indicate their thinking behind each drawing and their written reflections and suggestions in case the picture needed improvement.

Coding tasks using *Scratch*: Task B

Students had to formulate their own GBL challenge on a specific mathematics topic for learners. They had to plan their own diagram(s) to be executed by the sprite. Group members also had to include five *Scratch* images of block code with related output sequentially to indicate their thinking. The aim was to develop an activity for learners in *Scratch* where they can do programming in a play-based environment and develop CT skills. Creating their own game also needed high-order thinking skills (HoTS).

Activities 3–5: MS Teams meeting, MS PowerPoint presentation and reflections

Participating students engaged in the activities as mentioned earlier in three ways. Firstly, each of the twelve groups held an MS Teams meeting in which they reflected on their thinking processes and made suggestions on how to improve the tasks. They had to record their meeting and submit it as a six- to eight-minute video. Secondly, each group prepared an MS PowerPoint presentation to reflect on their group collaboration and responsibilities. Finally, the students concluded with reflective questions on the coding tasks. The researcher planned twelve open-ended questions on a Google Form that the students had to complete individually. These questions focused on students' feelings, online collaboration and group work, challenges and successes. A total of 43 students completed the individual reflective questions based on the coding tasks.

Assessment of computational thinking tasks

The final assignment of the semester focused on CT, which contributed to students' module marks. The lecturer (co-author) assessed each activity using a rubric, as shown in Table 5.1, which displays the assessment criteria for Tasks A and B.

Data collection and analysis

The following data were collected as part of the assignment:

- Own mathematics game
- *Scratch* programming Tasks A and B
- Video of each group's MS Teams meeting and their reflections
- MS PowerPoint presentation
- Each student's completion of the twelve reflective questions on Google Forms.

The researchers employed *in vivo* coding (also known as 'verbatim coding') to indicate students' actual words and phrases regarding their

TABLE 5.1: Lecturer's final semester's assignment assessment of each activity using a rubric displaying the assessment criteria for Tasks A and B.

Assignment 2: Computational thinking	Mark
Task A: Decagram (10-point star polygon)	
Five images copied: Block code with output	2
Efficiency, optimisation (2 ✓), reflection, debugging, testing (4 ✓)	6
Final output and correctness	2
SUBTOTAL	**10**
Task B: Own Scratch diagram	
Problem description: (1 ✓) Aim, (1 ✓) completeness, (1 ✓) detail	3
Five images copied: (1 ✓) Block code, (1 ✓) output	2
*Abstraction and decomposition	1
*Algorithm	1
*Cooperation	1
*Creativity	1
*Critical thinking	1
*Problem-solving and logic	1
*Efficiency	1
*Iteration	1
*Patterns	1
*Testing and debugging	1
Reflection	5
SUBTOTAL	**20**
TOTAL	**30**

Source: Authors' own compilation. Assessment criteria were based on the characteristics of computational thinking, as mentioned by Fagerlund et al. (2020) and Korkmaz et al. (2017).
*, These assessment criteria were based on the characteristics of computational thinking (CT) mentioned by Fagerlund et al. (2020) and Korkmaz et al. (2017).

experiences (Saldaña 2016, p. 105). The researchers manually analysed and coded the data and searched for ideas or concepts in the text. Researchers applied investigator triangulation to support reliable findings (Kelle, Kühberger & Bernhard 2019).

Findings

The emergent themes were (1) mathematics knowledge and skills, (2) student collaboration in game-based tasks, (3) the development of CT skills and (4) the promotion of SDL skills. The themes are displayed in Table 5.2 to Table 5.5. Quotations are presented verbatim and unedited.

The findings are presented in the 'Discussion' section.

Discussion

In this section, the research questions are answered. The first question aimed to determine the opportunities that are involved in game-based tasks to support student collaboration.

Students had both positive and negative experiences regarding their group activities and collaboration in game-based tasks. Most members were not used to programming, and the *Scratch* IDE was unknown to them. They addressed the challenge by watching relevant videos on *Scratch*, structuring their learning environment (WhatsApp and Telegram social networking applications, MS Teams meetings), setting reminders and deadlines according to a time frame and allowing for good communication between them. For example, several groups managed their learning activities, and members could choose specific tasks according to their strengths. This indicates

TABLE 5.2: Mathematics knowledge and skills.

Sub-theme	Students' responses to tasks
Mathematics skills	'We determined the number of degrees that the sprite should turn and then we started to code it. We made little mistakes like getting the sprite walk too short or turn in the wrong direction, but at the end our product came out good and looked like the decagram.' (Student, gender undisclosed, 29 November 2021) 'The *Scratch* program is a very creative way to teach learners the calculation of degrees and the lengths of a line on a graph […] and interesting way to learn patterns and directions. Each step the learners take will show the problem and solution of the previous steps.' (Student, gender undisclosed, 29 November 2021) 'It was enjoyable to calculate how big the angles must be that the sprite must turn and how the sprite must remain upright all the time. The layout of *Scratch* was often complicated and to bring mathematics into the picture, made it challenging […] [however] made me decide to do this with my learners in class one day.' (Student, gender undisclosed, 29 November 2021)

Source: Students' submitted responses from the Google Forms questionnaire forming part of and supporting the authors' data.

TABLE 5.3: Student collaboration in game-based tasks.

Sub-theme	Students' responses to tasks
Online collaboration and engagement	'Our plan was to watch YouTube videos, to get an overview of [CT] and to start planning properly. [...] We were on Telegram for the initial arrangements and assistance.' (Students, genders undisclosed, 29 November 2021)
	'We read the task individually and then discussed all aspects. Each member could choose different sections to complete according to their strong points.' (Student, gender undisclosed, 29 November 2021)
	'We had reminders of what [...] and when we were supposed to do it.' (Student, gender undisclosed, 29 November 2021)
	'I am full of confidence and grateful for my group. This is not our first assignment as a group; we grew together and overcame challenges.' (Student, gender undisclosed, 29 November 2021)
	'[*S*]o we put our heads together to try and figure it out [...] but everyone helped where they could.' (Student, gender undisclosed, 29 November 2021)
	'We had a meeting where we shared the work and set deadlines. [...] We worked within the time frame, did random checks on members. [...] We could see the group's progress on Google [*sic*] Forms, we could all edit.' (Students, genders undisclosed, 29 November 2021)
	'We had to do a lot of research, familiarise ourselves with CT and coding, get out of our comfort zone, ask for help, and reach out to the others.' (Student, gender undisclosed, 29 November 2021)
	'We had effective communication and collaboration among group members. The team gave their all.' (Student, gender undisclosed, 29 November 2021)
Group challenges	'The task was challenging, we had to move out of our comfort zone.' (Student, gender undisclosed, 29 November 2021)
	'[*E*]xcuses, doing work on the last minute, and not communicating effectively.' (Student, gender undisclosed, 29 November 2021)
	'[*C*]ollaboration was difficult due to language differences between the group members.' (Student, gender undisclosed, 29 November 2021)
	'Technology failed us and to receive sections of the work from other members was a challenge.' (Student, gender undisclosed, 29 November 2021)
Evaluate group work	'Great communication amongst members, respect for one another.' (Student, gender undisclosed, 29 November 2021)
	'We allowed time to share ideas and on the group. We had a discussion, chose the best option and shared the work, task was compiled and reviewed.' (Student, gender undisclosed, 29 November 2021)
	'We worked together well as a group and I believe we submitted a task of good quality.' (Student, gender undisclosed, 29 November 2021)
	'This section helped us to overcome our pride and ask for help: more minds are better than one.' (Students, genders undisclosed, 29 November 2021)
	'We have done our best as a group. I really enjoyed it.' (Student, gender undisclosed, 29 November 2021)
	'I am part of a hard-working group. I knew that we would succeed even if we struggled.' (Student, gender undisclosed, 29 November 2021)

Source: Students' submitted responses from the Google Forms questionnaire forming part of and supporting the authors' data.

TABLE 5.4: Development of computational thinking skills.

Sub-theme	Students' responses to tasks
Algorithmic thinking	'We wanted to make a spiral design with different colours, degrees, and pen sizes. We solved this problem with the correct block codes.' (Student, gender undisclosed, 29 November 2021) 'We coded so that the sprite got to the end of the diagram, with three perpendicular sides attached to each other, turning 18° each time and which is repeated five times.' (Student, gender undisclosed, 29 November 2021) 'We repeated the code ten times. The angles were 108°. In this way, the lines did not pass but met each other, and the decagram was correct.' (Student, gender undisclosed, 29 November 2021)
Abstraction and decomposition	'It was enjoyable to calculate how big the angles must be that the sprite must turn and how the sprite must remain upright all the time.' (Student, gender undisclosed, 29 November 2021) 'We determined the number of degrees that the sprite should turn [...] at the end our product came out good and looked like the decagram.' (Students, genders undisclosed, 29 November 2021) 'We just changed the angles until we found the correct angles to make the shape perfect.' (Student, gender undisclosed, 29 November 2021)
Pattern recognition	'The *Scratch* program is a very creative way to teach learners the calculation of degrees and the lengths of a line on a graph [...] and interesting way to learn patterns and directions. Each step the learners take will show the problem and solution of the previous steps.' (Student, gender undisclosed, 29 November 2021)

Source: Students' submitted responses from the Google Forms questionnaire forming part of and supporting the authors' data.
key: The degree symbol (°) represents the angle rotation of which one full rotation is 360°.

cooperation (Johnson & Johnson 2018; Korkmaz et al. 2017), where members are actively involved and choose specific roles. Students did considerable research, brainstormed, assisted each other and selected the best solution. In addition, group members monitored their progress and used Google Forms to share suggestions, reflect on their thinking and conduct random member checks. One student noted, 'This is not our first assignment as a group; we grew together and overcame challenges' (see Table 5.3). Members were also positive that they would succeed and submit a good assignment. Unfortunately, some groups experienced threats, such as excuses for not completing activities and postponement of individual tasks. Language differences were further issues, and sometimes technology was a limitation when students worked online during COVID-19. As a result, most students experienced GBL as positive, as it provided for developing new knowledge, enhanced each other's learning and supported their strengths as a group. Results indicated that games and a playful learning environment develop students' CT skills through group activities. The findings are aligned with Tsarava et al. (2018), who claim that GBL motivates learners to interact with each other and to develop essential programming skills.

The second research question investigated how mathematics students developed CT in game-based tasks. Students were actively involved and

TABLE 5.5: Promotion of self-directed learning skills.

Sub-theme	Students' responses to tasks
Identify own learning gaps	'In the beginning, I struggled a lot to understand and learn *Scratch* and to sketch the shape, but in the end, I was successful.' (Student, gender undisclosed, 29 November 2021)
	'I had no experience of coding, to attempt difficult objects, without guidance/teaching on the program.' (Student, gender undisclosed, 29 November 2021)
Learning motivation	'I was motivated. I like career challenges […] felt relaxed and confident in myself. […] Yes, I am full of confidence and grateful for my group.' (Student, gender undisclosed, 29 November 2021)
	'I was motivated to complete the assignment as I like career challenges.' (Student, gender undisclosed, 29 November 2021)
	'I was not too confident. I thought that we would struggle, but with research and understanding new info, we will manage.' (Student, gender undisclosed, 29 November 2021)
Curiosity and taking initiative	'We first had to play around with *Scratch* and had to help each other and work together to figure it out.' (Student, gender undisclosed, 29 November 2021)
	'We read the task to understand, shared ideas and decided what will work best.' (Student, gender undisclosed, 29 November 2021)
	'It was fun to experiment with a new app to make different unique shapes by using codes. We learnt a new skill: make different shapes, use colours, and pen sizes using a coding app.' (Student, gender undisclosed, 29 November 2021)
Monitoring and reflection	'I had an opportunity to learn about coding […] it allowed me to think out of the box.' (Student, gender undisclosed, 29 November 2021)
	'This was a very fun and creative assignment – we had to go out of our comfort zones to complete this assignment.' (Student, gender undisclosed, 29 November 2021)
	'Our coding was not going to work. We managed to justify the mistakes and correct them.' (Student, gender undisclosed, 29 November 2021)
	'I trusted that my group would do it well, but I was concerned that I will disappoint the group as I am not competent with coding.' (Student, gender undisclosed, 29 November 2021)
Persistence	'At first, we were way off target, our coding wasn't going to work, but we managed to justify the mistakes and correct them.' (Student, gender undisclosed, 29 November 2021)
	'It took more than five attempts to get on the right track for both diagrams. With each attempt we got closer and closer to the […] diagram.' (Student, gender undisclosed, 29 November 2021)
	'Although we struggled a bit with the coding, in the end it was quite fun to do something different.' (Student, gender undisclosed, 29 November 2021)
Critical judgement	'I enjoyed the *Scratch* tasks as I had to use more brain power than for any other maths problems.' (Student, gender undisclosed, 29 November 2021)
	'If I could redo the tasks, I would add more content and explain everything better.' (Student, gender undisclosed, 29 November 2021)
	'The assignment was challenging me to think critically and be creative since it deals with mathematics and CT.' (Student, gender undisclosed, 29 November 2021)
	'I will do it on my own, put in more effort to ensure that it is of good quality. […] Yes, there is always room for improvement. I will take part in both sections and do more research on computational thinking.' (Student, gender undisclosed, 29 November 2021)
Responsibility in learning	'We each had our own responsibilities regarding this assignment, but everyone helped where they could.' (Student, gender undisclosed, 29 November 2021)
	'We read the task individually and then discussed all aspects. Each member could choose different sections to complete according to their strong points.' (Student, gender undisclosed, 29 November 2021)
	'I created a checklist, based on the rubric which helped me to stay on course with the activity. By using the checklist, I was able to see what I needed to do and when I needed to do that part.' (Student, gender undisclosed, 29 November 2021)

Source: Students' submitted responses from the Google Forms questionnaire forming part of and supporting the authors' data.

employed creative ways to design a game based on a mathematics topic. At first, students experienced feelings of despair, anxiety and stress. It was a challenging task for students to 'think computationally, not just mathematically' (Wing 2006, p. 3). Despite these feelings, they became more confident and motivated as they progressed. Students' collaboration showed their initial planning, monitoring and reflection on their progress and the resources used. When drawing the 10-point star polygon and constructing their own programming activity, members had to apply algorithmic thinking, integrate the relevant coding blocks and produce the required output. Appropriate planning and design were essential. Some examples were a spiral with different colours, degrees and pen sizes and a diagram with 'three perpendicular sides attached to each other, turning 18° each time and which is repeated five times' (see Table 5.4).

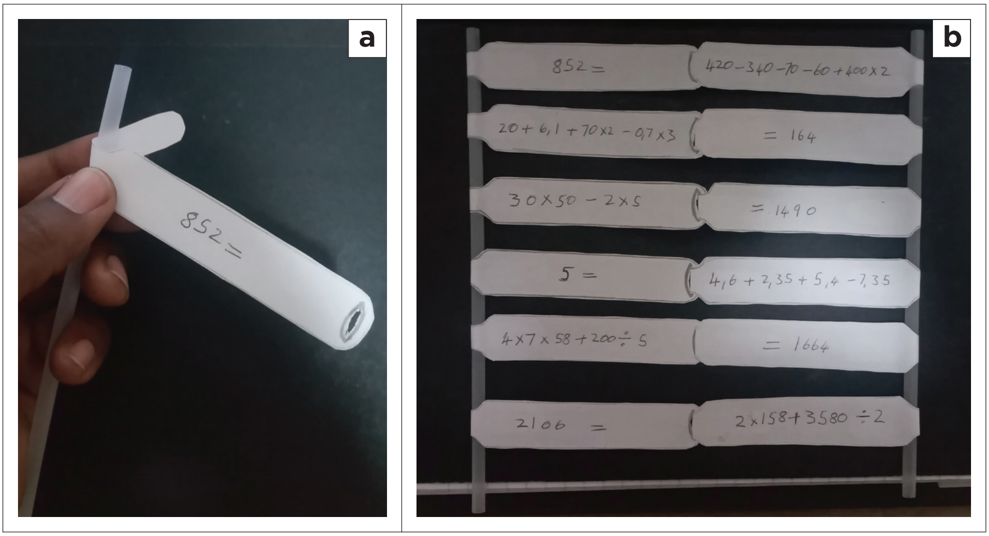
A few examples of *abstraction and decomposition* were mentioned. An example is the 'Among Us' tour game (Group 4), where students would expect learners to study the route, position and movement, decide which path to follow and how to convey the directions and choose the best route. It was essential to focus on the relevant requirements and break down the problem into smaller parts to solve it. Regarding the coding of Tasks, A and B, one of the groups made some mistakes, such as the sprite walking too short a distance or having it turn in the wrong direction. However, they could reflect on their thinking and accomplish the task. Some students changed the coding until they found the right angles to perfect the shape. Unfortunately, such an approach could indicate a trial-and-error strategy as it involves several attempts until students find the correct angles for the sprite to execute.

One example of *pattern recognition* emerged in Activity 1, where Group 4 constructed a task using plastic straws and glue and requested Intermediate Phase learners to apply the correct rule regarding the order of mathematical operators: *Bracket*, *order*, *division*, *multiplication*, *addition* and *subtraction* (BODMAS) in solving a problem (Figure 5.4).

Another example using patterns was the following (see Table 5.4):

> 'The *Scratch* program is a very creative way to teach learners the calculation of degrees and the lengths of a line on a graph [...] and interesting way to learn patterns and directions. Each step the learners take will show the problem and solution of the previous steps.' (Students, genders undisclosed, 29 November 2021)

Regarding the goals of CT (see 'Development of computational thinking'), students applied some ideas (*personal mindset*) to create and solve a problem, engaged in online *social interaction* to solve problems jointly, *complemented* mathematical thinking with CT and *applied* these in a



Source: Photographs (a) and (b) taken by Group 4 on 31 October 2021 in an unknown location. Contributed by the co-author of this chapter, Tertia Jordaan, and published with the appropriate permission (and informed consent) from the group members and Tertia Jordaan.

FIGURE 5.4 (a & b): Joined stranded boxes to indicate the order of operators.

game-based task as based on Wing's view of CT (Wing 2006). These examples also related to the four integrated goals of CT, as mentioned by the authors and shown in Figure 5.1.

The third question explored which affordances CT provides towards students' SDL. Completing the CT assignment was challenging for the students. Participating students mentioned several examples of self-directed abilities: For example, they identified some learning gaps. Even though mathematics students had no experience with the *Scratch* IDE or coding, they shared some ideas and assisted each other in participating in the challenge and learning new skills. Initially, some students struggled and 'figure[d] it out'; while others were confident to take up the challenge: 'I am full of confidence and grateful for my group' (see Table 5.5). In addition, students struggled with the coding, and some used several attempts to solve the problem while others were 'off target'. Nevertheless, they persisted, reflected on their thinking and corrected mistakes.

Participating students were curious and learnt how to program and create shapes by integrating different colours, pen sizes, angles and sounds. Although they had individual responsibilities, everyone assisted, discussed the issues and allowed members to choose different sections according to their strengths. One participant mentioned, 'I will [...] put in more effort to ensure that it is of good quality', while another used a checklist to reflect on her learning and to ensure that all requirements had been addressed.

Group work was essential, and students learnt programming in *Scratch*, executed their plans, searched for relevant information, identified the best solution and developed a profound understanding of CT and mathematics. This notion is supported by Turchi et al. (2019), who focused on group collaboration and students' involvement in GBL to promote CT abilities. Furthermore, some affordances related to CT were the development of several SDL skills. In this regard, Threekunprapa and Yasri (2020) emphasise that CT requires reflective thinking and SDL abilities to succeed in challenging tasks. This was evident from students' motivation to learn, their initiative and the management of their learning processes, and their persistence in addressing programming challenges and developing their own games.

Recommendations and limitations

Recommendations to improve the future quality of CT tasks include the following:

- An introductory lesson and practical activities in *Scratch* prior to the assignment.
- Specific guidelines on students' collaboration and interaction and reporting of non-collaborating students.
- Face-to-face classrooms could provide more opportunities and strengthen student engagement in GBL.

One of the limitations of this study is that the research cannot be generalised, as a small number of students participated. Moreover, the GBL tasks were done where students mainly worked online, and some experienced technical challenges.

Conclusion

This chapter aimed to explore mathematics education students' active involvement in game-based tasks to provide opportunities for developing CT skills. Findings indicate that students developed some CT skills, collaboration and self-directed abilities. Future research on the development of CT, the effects of a face-to-face environment, suitable game-based teaching–learning strategies and the effect on SDL is recommended.

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Chapter 6

Introduction to computational thinking in geometry through a LOGO problem-based learning experience with high school learners in Morocco

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Abstract

Geometry as a subject remains a challenge for most learners from primary school onwards. Indeed, numerous difficulties arise in learners' learning, such as a lack of motivation, a lack of abstraction and the discontinuity between theoretical and concrete concepts, which directly influence the attractiveness of mathematics courses in general and geometry in particular. To motivate students to develop their abstractions and concretise their knowledge in geometry for self-directed learning (SDL), we developed problem-based pedagogical sequences in coding based on the LOGO language pedagogical environment in education. An experiment was conducted with an experimental group from the secondary high school level. They were introduced to the visual environment that facilitates the creation of geometric shapes within the context of pedagogies of play (PoPs) and SDL. A control group of 20 students also did the same exercises but followed a more classical approach. At the end of the experiment, both groups' results were compared. The results show that the learners' yield in the experiment using coding was better than that of the classical approach. This problem-based learning (PBL) and computational thinking (CT) approach – infused with elements of play pedagogies – was deemed successful. Moreover, fostering SDL via coding can be optimised through learner involvement, leading to improvements in their abstractions, which finally develops their mathematical skills.

Introduction

The current trend in education systems worldwide is introducing computer coding in the classroom (Ouahbi et al. 2017). Several governments, such as Bulgaria, Cyprus, Denmark, England, Estonia, Greece, Ireland, Poland, Portugal and South Africa, have already or are considering including coding in their school educational curricula. Coding integration allows cross-curricular skills development in learners, particularly CT (Yildiz Durak 2020). Wing (2006, p. 33) defines CT as 'a skill that involves solving problems, designing systems, and understanding human behavior, by pressing the fundamental concepts of computer science'. Hence, this chapter aims to explore the possibilities for CT in geometry through a LOGO PBL experience fostering SDL with high school learners in Morocco.

Within this context, PBL was viewed as a process in which students follow triggers based on a specific problem or scenario, after which they determine their own learning objectives (Wood 2003). Furthermore, as we consider PBL supportive of fostering SDL, it is essential also to define the parameters of what is understood as SDL. We regard SDL – as defined by Knowles (1975, p. 18) and as mentioned in Chapter 1.

Within this context, this research specifically focused on CT in terms of PBL for SDL. Computational thinking is not exclusively relevant to computer science as a subject but can also be regarded as a competence (Hsu, Chang & Hung 2018). Research has shown that coding can be a good mechanism for developing this skill. The machine is essentially an entity that can speak mathematics, and learning to speak with the computer (i.e. coding) can prove to be one of the most 'natural' ways of doing mathematics (Papert 1981). Conversely, the view of Dijkstra (1970) is that programming is indeed not a form of mathematics but rather science. The machine always responds to the question posed to it – it is for the user to penetrate the logic to be able to use its power better; this learning supposes a decentration between our thought system and its operating system (Mendelsohn 1985). In short, the machine can only reflect and concretise human thought to the computer, which may seem boring and repetitive but can also be considered ingenious and imaginative to people, according to Wing (2006).

Using coding through LOGO is quite appropriate within the context of PBL for SDL and allows for learning through play and research to be conducted. A typical situation could be as follows: The student receives a drawing they must reproduce using the 'turtle' in the software. It could be a figurative drawing, an attractive motif, a frieze or a fractal. Seymour Papert's objectives in developing the LOGO language go beyond mathematics education. Experience has shown that most students are happy to engage in this type of activity, in which they have the freedom to experiment, solve problems and do without the teacher to evaluate them. This brings an element of play into the classroom, as was shown in earlier research on using LOGO (Shier 1991; Silvern 1988) and contributes towards building a play-based pedagogy (see ch. 2) (Lunga, Esterhuizen & Koen 2022; Miller & Saenz 2021; Pyle & Danniels 2017).

Results of a classroom experiment in CM2 (in French *cours moyen 2*, Grade 2 primary school level) in France show that learners have greater success with LOGO compared to learners in the traditional environment, with a significant difference (50% and 40%) for the two years, for the diagonal of a square (□), and fairly significant success (27% and 17%) for the two exercises of reproductions of hexagonal (⬡) and pentagonal (⬠) rosettes (Gobert 1992). In these activities, learners develop and construct knowledge about an object. The LOGO social networking activity in a learning environment in practice intervenes as a different and complementary way of approaching a notion or a theme of geometry (Gobert 1992). On the other hand, for Piaget – regarded as the founder of constructivist theory – thought develops in the same way. Constructivist theory, followed by many pedagogues, didactics and psychologists, was evoked not only to have discourse on learning but also observation of the processes implemented by the subject who is confronted with resolving a problem (Servant-Miklos 2019). With our research, the learner can approach a large part of the concepts of classical geometry, including angles, symmetry and polygons. Learners actively participate in discovering the theorems and properties of the figures they construct (Mendelsohn 1985).

Our work combines the computational approach, neo-papertism and the constructivism of Piaget in a mathematical problem related to constructing a geometric figure. The decomposition of a problem into small parts or subprocedures and the abstraction, generalisation and elaboration of sequences and solutions tracks, also noted as 'algorithms', lead to organising own knowledge and building new tools through play.

Our goal in this chapter was to study the extent of CT through LOGO coding employing PBL for SDL in mathematics. We also explored whether using this tool in class studying geometry could positively impact the level of abstraction of learners and the development and construction of other skills related to problem-solving.

Background and issues

Learners and mathematics

Learner motivation in terms of learning mathematical skills is highly relevant to this research. Similarly, when approaching SDL, the importance of motivation extends beyond just the subject of mathematics, as Randy Garrison identified this aspect as one of the dimensions of SDL. In this context, Garrison (1997) distinguishes between motivation, self-management and self-monitoring as dimensions of SDL. He states explicitly that motivation 'plays a very significant role in the initiation and maintenance of effort toward learning and the achievement of cognitive goals' (Garrison 1997, p. 26). Consequently, learners' motivation would influence not only their SDL but also their progress in mathematics and, ultimately, also CT.

According to the results of the 2012 Programme for International Student Assessment (PISA) (Organisation for Economic Cooperation and Development [OECD] 2016a), learners often show evidence of mathematics anxiety and lack of motivation, but this varies between countries and contexts. In some countries – including Belgium, Korea, Spain, Finland, France, Iceland, Italy, Latvia, the Netherlands, Portugal and Serbia – less than half of students who say they are interested in what they learn in mathematics eagerly await their mathematics classes (OECD 2016a). Intrinsic motivation tends to diminish gradually; students are less interested in mathematics and take less pleasure in their studies.

This study's results were confirmed in 2015 (OECD 2016b), which showed that learners in developing countries experienced the highest anxiety levels in learning mathematics obtained fewer satisfactory results. The worst-performing countries in mathematics were those with a score of less than 400 points in the PISA events. Conversely, learners in countries above the OECD average – including Germany, Austria, Denmark, Finland, Liechtenstein, the Netherlands and Switzerland – tend to experience the lowest anxiety levels towards learning mathematics. In fact, Morocco – unlike Algeria and Tunisia, Jordan, Qatar and the United Arab Emirates (UAE) – was absent from the PISA 2015 edition (OECD 2016b). The survey published by the OECD is based on data collected in 2015. Tunisia and Algeria, the only Maghreb countries (region of North Africa bordering the Mediterranean Sea) that participated in this ranking, obtained 65th and 69th place, respectively. The best performances were recorded in Singapore, Japan and Estonia. PISA significantly relates to an international assessment of specific skills and knowledge of fifteen-year-old learners, which covers three areas: Reading, science and mathematics. The evaluation of the last edition in which Morocco participated was entirely computer-based.

Attitudes towards mathematics allow explaining (at least in part) the mathematical skills of learners (Dowker et al. 2019; Winarso 2018). Multiple regression shows that intrinsic motivation, instrumental motivation and anxiety of learners can predict performance in mathematics (Ouellette 2013). This does not surprise us as much – motivation is the main engine of any learning process (Mitchelmore & White 2007), whereas anxiety threatens the smooth running of this process. In this context, a learner-centred approach is also envisaged. Then again, generalisation is, like abstraction, a necessary process for building mathematical knowledge and therefore plays a fundamental role in learning the reasoning articulated with geometric figures (Richard 2004). In addition, these are the main components of geometric thinking we aim to develop in learners. Abstractions can arise from learning in diverse ways, including familiarising learners to find relevant contexts, recognising the commonalities between contexts and encouraging learners to feel the same thing so that they potentially then form some universal concept which can then be applied in new situations that may arise (Mitchelmore & White 2007).

Abstraction is one of the concepts of CT (Wing 2006) (see ch. 5). Computational thinking could be considered as both a cognitive tool in which the learner's commitment necessarily involves developing a different relationship to error – especially during a coding process and a problem-solving process – and an essential skill, a combination of algorithms and logical-mathematical reasoning, a complex construct. Thus, coding is a skill that allows not only immediate feedback but also an opportunity to hypothesise, anticipate and reflect using logico-mathematical relationships (DeBlois 2016) and, by implication, employ higher-order thinking skills (HoTS) (Popat & Starkey 2019). Therefore, it seems important that educational systems give learners an intrinsic and extrinsic interest in mathematics. Importantly, mathematics anxiety could be reduced by investing in tools and their pedagogical reports (Adihou 2011).

According to the Singapore method of mathematics education, which involves problem-solving through figures as well as diagrams (Juarez Eugenio & Aguilar 2018), it is our brains that create the images that we see in reality: the passage from the abstract to the concrete through the image vice versa is the most difficult way to solve a problem, to reason, break it down, reformulate it, model it, and to execute procedures and algorithms (Modeste 2012).

This research was carried out given the acute lack of this type of research, which aims to introduce CT and coding into mathematics education within the identified context. We proposed to think about these questions simultaneously following a short activity involving a coding activity in the course of geometry. This work assumes that coding learning could enhance the ability to solve problems. The research questions posed were:

- Could this type of LOGO coding influence the learning of problem-solving in mathematics, especially in geometric construction?
- How can problem-solving skills in geometry be developed using the LOGO coding environment?
- How can playful LOGO coding be used as an approach to motivate learners?
- How can playful LOGO coding contribute to fostering SDL?

Choice of language

Why did we choose the LOGO language? For the experiment to be feasible, the software used had to meet certain essential criteria.

The LOGO language generally met the listed criteria. Wally Feurzeig, Cynthia Solomon, and Seymour Papert developed LOGO in 1967 (LOGO Foundation 2015). This coding language aimed to allow children to use computers to simulate, build, draw and create – essentially learning through play. This language was part of a project drawing on the work of Piaget and involved combining cognitivist views in terms of artificial intelligence (AI) and learning theories explored by Marvin Minsky and Seymour Papert at the Artificial Intelligence and Computer Science Laboratory of Massachusetts Institute of Technology (MIT) (Minsky & Papert 1972). Minsky and Papert have even developed a 'social theory of the mind' that defends the general idea that any system is based on relatively independent subsystems.

According to Papert, LOGO plays three roles simultaneously: A *coding language*, a *theory of learning* and a *material device* (Mendelsohn 1985). The limitations of the LOGO environment in computer literacy were related to a lack of autonomy (Resnick et al. 1996). Compared to other programming approaches, the specificity of the LOGO approach is that the latter has been characterised as part of pedagogical robotics. In this environment, coding learning is done by playing games focused on problem-solving (Nijimbere 2014). Since the original launch of LOGO, this language has been extended to other online iterations, such as *TurtleBlocks* and *NetLogo* (Dhakulkar & Olivier 2021).

Coding by LOGO: Learning in a fun way and initiating computational thinking through problem-based learning

In this environment, learning is done playfully by playing and coding simultaneously, which reduces anxiety and encourages learners to engage in the learning process. The immediate perception of the consequences of using commands allows learners to appropriate the syntax of language gently. As a counterpoint, using LOGO provides a unique way through which language can be utilised in determining commands and this, according to the literature, has proved to be effective from a didactic viewpoint (Guieu 2009). Furthermore, it has been found that LOGO provides an apt environment for PBL. In this regard, Çukurbaşı and Kıyıcı (2017) found that PBL activities could be facilitated through LOGO and that this contributed positively not only to student success but also motivation in the learning context especially if this is combined with a flipped-classroom approach. This aligns well with other research on PBL in mathematics contexts, where it was determined that such an approach motivated students when they collaborated in problem-solving activities (Botty et al. 2016).

Furthermore, programmes facilitating coding languages, such as LOGO, present opportunities in terms of the current trend in play-based education by introducing visual environments such as *Scratch* (Dhakulkar & Olivier 2021; Wilson, Hainey & Connolly 2013) and *Kodu* (Stolee & Fristoe 2011) makes coding fun and accessible to young children (Dagiene et al. 2013). Projects that focus on creating games, animations and stories with coding environments, such as *Scratch 2.0* (MIT Media Lab 2022) and *Alice 3.6.0.3* (Carnegie Mellon University 2021) have also been developed (Ouahbi et al. 2017). After a study of the correlation between programming games and mathematics tests (Lewis & Shah 2012), learners acquired significantly more positive attitudes towards this discipline.

The more recent findings around using *Scratch* also show positive results and affordances that are similar to the use of *Scratch* coding, accelerating the learning curve. However, the effect has been twice as great in social studies as in mathematics, and the greatest effect is the result of a more positive adjustment between cognitive as well as certain motivational factors; learners working in social studies have shown higher levels of pleasure as well as confidence in the process of self-directed learning (Moreno-León, Robles & Román-González 2016). The results led to new questions that prompt more in-depth investigation into the differences as regards the educational impact of coding according to the subject or chosen activity. The potential of serious games and coding by *Scratch 2.0* has been proven as a pedagogical tool to involve learners in mathematics classes and thereby improve their academic performance (Zavala, Gallardo & García-Ruíz 2013). In addition, research has shown, in terms of PBL, that problem-solving skills can be developed while using *Scratch 2.0* (Brown et al. 2008; Calao et al. 2015; Ching-San & Ming-Horng 2012; Denning 2009; Kalelioğlu & Gülbahar 2014; Resnick 2013), but there are no significant differences in any of these studies (Lai & Yang 2011). The limitations of the LOGO environment in computer literacy are related to a lack of autonomy (Resnick et al. 1996). Consequently, this emphasises the need for interventions focusing on SDL. In this regard, any such implementation should involve opportunities for learners to take charge of the learning process alone or collaborative in determining their needs in terms of learning and then also setting specific goals and choosing relevant learning resources and strategies towards reaching the set goals and then also evaluating the process (cf. Knowles 1975). Furthermore, for this chapter, the aspect of computation thinking was a key part of the broader conceptual framework underpinning the intervention.

Computational thinking: Conceptual framework

Design

The new direction of computation in the classroom is to solve problems either in a disconnected way or by using technology, which can improve learners' critical thinking, logical reasoning, community, creativity and communication skills, which are the most in-demand in the 21st century. These aspects also relate to many of the skills associated with SDL (Olivier 2019). Furthermore, the assessments in this research were structured to support PBL (cf. Wood 2003). Computational thinking means using abstraction and decomposition when dealing with a large and complex task or designing a large and complex system; separating the different aspects; selecting appropriate ways of representing a problem or modelling some pertinent aspects of a problem to make them accessible.

Moreover, thinking similarly as a computer programmer means much more than knowing how to program – it also requires functioning at several levels of abstraction (Van Bakel & Lescanne 2008). Computational thinking is one of several skills whose application is not limited to computer programmers; it is regarded as a set of attitudes and skills that are considered universally applicable (Wing 2006). This approach can be divided into four main categories:

- **Decomposition:** Understanding that to solve a complex problem, it must be broken down into several simple problems; the learner correctly solves all the subproblems related to the modelling process; and the detection of variables and the relationships and connections between them according to a specific model.
- **Pattern recognition:** Understanding that a new problem would likely be linked to other problems already solved by the learner.
- **Abstraction:** Comprehending a problem and its solution at different levels, then extending the solution of similar situations independently of the context.
- **Algorithms:** Thinking about tasks that must be accomplished in a series of steps (Tchounikine 2017).

Concerning the computational approach – problem-solving around the theme of the geometric construction of the shapes in question – we have adopted three phases: mathematical, algorithmic and computer, and the passages between them where the learner translates on the machine the algorithms prepared in advance and consequently the mathematical concretisation and didactic transposition of the mathematical model to a computer model (Balacheff 1994) via the algorithmic model (Chevallard 1986).

Each CT concept corresponds to one or more phases (cf. Table 6.1):

1. Decomposition (Phase 1).
2. Recognition of shapes, identification, trial and error, and appropriation of the problem (Phase 1).
3. Abstraction and decontextualisation (Phase 1, Phase 2).
4. Generalisation (Phase 2, Phase 3).
5. Execution of algorithms (Phase 3).

Attitudes and skills targeted

In this research, certain specific attitudes and skills were targeted in the process of facilitating CT through LOGO coding using PBL for SDL, namely:

- **The innovative spirit:** Improving analytical, organisational, collaborative, logical and critical thinking.
- **Self-confidence:** Developing learners' autonomy, risk-taking and free expression of their viewpoints.
- **Profitability:** Being part of new material that is useful for many trades and fields.
- **Efficiency:** Learning to solve a problem more accurately and in a short time.
- **Creativity:** Creating new avenues for the solution.
- **Learning through play:** Using play as a way of acquiring new skills.
- Computational thinking-related skills as well as more general skills, all of which can be worked on in fields other than mathematics.

In terms of CT, other skills that were covered included (1) knowing how to be able to break down a problem into simple tasks, (2) knowing how to recognise tasks that have already been performed or are repeated (reusability of codes and repetition of schema), (3) learning to work together on a common project (this thinking promotes autonomy and collaborative work) and (4) fostering imagination to develop short and effective solutions.

TABLE 6.1: Factors considered to meet the criteria.

In terms of the environment	At the level of language
• Ability to create new procedures in an interactive way • Ability to simulate movements • Ability to assimilate knowledge from own sensory-motor knowledge • Possibility of concretely representing one's own thoughts	• Be easy to handle and manage • Have a simple syntax • Be usable on the command line to get an immediate result

Source: Bruillard (1997).

In order to evaluate these attitudes and monitor their evolution, we were interested in motivation, a coding situation, an algorithmic approach, structuring and the evolution of the coding, as well as errors committed during the execution.

Methodology and method

Research design and methodology

This quantitative quasi-experimental study involved comparing pre- and post-tests of an experimental and a control group of learners. This research adhered to all relevant Moroccan research ethics and permission requirements. Ethics approval was also obtained for this research to be conducted.

Sample

Among the 210 learners distributed into six classes in the second year of secondary school, a class of 40 learners was randomly selected and then divided into two groups: (1) An experimental and (2) a control group. Only learners with parental permission and who assented to participating in this research were involved.

Approach

We conducted workshops in class while using appropriate assessments to test our approach. Despite both groups being exposed to LOGO earlier, the control group handled the allocated sections through a more traditional approach. While the experimental group was supported in PBL through tasks based on authentic problems and, in line with the approach followed by Botty et al. (2016), learners collaborated with peers in solving the problems. Because of the age of the learners, the teacher acted as a facilitator throughout the process and fostered more independence among the learners as the process progressed. These latter learners were also prompted to take charge of their learning and resource selection towards fostering their SDL. For the sake of the research ethics, the control group also had the benefit of exposure to the PBL tasks on LOGO after the intervention was concluded.

A pre-test, post-test and survey for both groups were conducted based on official instructions for secondary mathematics instruction (Table 6.2). For this level, learners must know how to build simple geometric shapes to calculate the quantities (e.g. angle, perimeter and surface) and to use trigonometric relationships.

TABLE 6.2: Excerpt from Moroccan mathematics official instructions of the second level at secondary school.

Assignment	Clarification
• Create some common geometric shapes (rectangle, triangle, rhombus, etc.) • Measure and compare the lengths, perimeters, areas and angles of some geometric shapes in the plane	• Observation, experiment and deduction of results depend on presenting the various characteristics related to the concepts mentioned in this paragraph through various activities that employ the various available means while taking care of the engineering constructions; as for proof, it is not presented except in cases where appropriate • Most of the basic concepts mentioned in this paragraph are familiar to learners, and therefore there is no need to define them • Care should be taken to highlight the relationships between the parts of the plane and make the learners correctly use some terms such as straight, half straight, segment, segment to measure segment, straight perpendicular to straight, straight parallel to straight, straightness of points, axial symmetry, mid-segment, mid-angle and triangle height • On each occasion, the notion of distance is exploited and linked to geometric issues

Source: Authors' own work.

For this purpose, learners from a selected public school of the Regional Academy of Education and Training (AREF) of Marrakech-Safi were sampled. The pre-test and the post-test were prepared to evaluate and confirm or reject our hypotheses. The experimental group focused on creating a PBL environment through which SDL could be fostered in their usage of LOGO.

Pre-test

The purpose of this test was first to evaluate the learners' achievements in geometric construction and related concepts (angles, orthogonality, parallelism, axial symmetry, etc.) and then to study the homogeneity of the two groups. The test consisted of reminders of the basic notions of geometry seen in the first year of secondary school, followed by a test of 20 questions spread over different axes made to diagnose and test.

Coding knowledge

Note that all classes at this level have already studied the LOGO coding course in the computer curriculum. Learners were introduced to the notion of algorithms and concepts, such as the basic LOGO primitives: Sequence, variables, iteration [loops], structures, functions, procedures and conditions.

Post-test

The experimental group, such as the control group, underwent a knowledge test. The test consisted of 20 questions distributed on different axes made during geometry. The post-test consisted of a set of criteria that allows the five concepts as mentioned earlier in CT to be included. The development of the skills studied in this research during the experimentation phases was then evaluated.

In addition to the assessment to measure the degree of development of learners' skills, a survey was simultaneously prepared and applied to the experimental group in the form of a questionnaire consisting of 20 questions. A questionnaire and an evaluation grid were chosen to process and analyse the attitudes and perceptions of the learners being tested. According to this criterion, learners would undergo an assessment of perceptions and attitudes, indicating whether they are 'well satisfied', 'satisfied', 'not very satisfied' or 'not satisfied'.

Post-test and questionnaire criteria

Evaluation criterion

Students should receive feedback, from the writing of programs to their execution, objectively evaluate their programs based on tests, and modify and improve them to adapt them to similar situations.

Attitude and perception criterion

The objective of this criterion is to reference attitudes downstream of the treatment resulting from the results of the self-assessment and summative assessment, which demonstrates motivation, cooperation, commitment, independence and belonging simultaneously and, as such, gives some sense of learners' self-directedness.

Conducting the experiment

After the pre-test of both groups:

- The control group learners were invited to a mathematics session to draw the geometric shapes (i.e. equilateral triangles, hexagons, octagons, pentagons, rectangles and squares) in a classical way using traditional didactic tools.
- The experimental group learners had already initiated drawing the same shapes (i.e. equilateral triangles, hexagons, pentagons, rectangles and squares) through LOGO during the sessions. Each learner was invited, too, as in the case of the control group.

The practical work was carried out in the school's computer room, equipped with ten computers (Figure 6.1) over six classes and six weeks. Thus, the

Source: Photograph taken by the authors of this chapter, published here with informed consent and adequate permission received from the respondents and chapter authors.

FIGURE 6.1: Fun activities within the LOGO environment.

experimental group was grouped in pairs during the practical sessions. The different activities that were carried out are described in Table 6.3.

Processing of experimental data

For our experiment, the learners were led, on the one hand, to pass a formal test as part of the summative evaluations and, on the other hand, to answer a diagnostic questionnaire on motivation and perception. Thus, the data from the experiment were processed in two parts.

Component 1: Assessment by a knowledge test

Learners were assessed on the concepts and skills covered in six exercises:

1. **Exercise 1:** See the control of decomposition.
2. **Exercise 2:** Test learners' knowledge in basic notions of pattern recognition, identification, trial and error, and appropriation of the problem at hand.
3. **Exercise 3:** Test the level of abstraction and decontextualisation.
4. **Exercise 4:** Diagnosing skills concerning generalisation.
5. **Exercise 5:** Assess learners' learning outcomes in basic concepts of combining partial solutions into a single overall solution.
6. **Exercise 6:** Study a more complicated case to exploit all the concepts of CT, from decomposition to algorithm.

TABLE 6.3: Activities carried out during the experiment.

<table>
<tr><th>Items</th><th>Experimental group</th><th>Control group</th></tr>
<tr><td>Mathematical phase</td><td>• Reminder of the theoretical notions of geometry:
◦ The sides
◦ The angles
◦ Parallelism
◦ Orthogonality
• Trace written on the board of formulas recalled necessary
• Resolution procedure (Phase 2: Design)</td><td>-</td></tr>
<tr><td>Algorithmic phase</td><td>In this phase, learners are asked to:

• Design the geometric construction of shapes respectively (square, rectangle and equilateral triangle); however, they must not fumble but get it directly inspired by reminders and work done in class during Phase 1
• Study the relationship and connection between the number of sides (number of angles) and the value of an angle of rotation indicated on the white sheet where the constructions must be made
• Calculate the number of sides and the angle of rotation for the first three shapes, respectively (square, rectangle and equilateral triangle)
• Calculation (number of sides * angle of rotation) for each
• Gathering results in a table in this form:

<table>
<tr><th>Form</th><th>Number of sides (Ns)</th><th>Angle of rotation (Θ)</th><th>Number of sides * angle of rotation (Ns * Θ)</th></tr>
<tr><td>Square</td><td></td><td></td><td></td></tr>
<tr><td>Rectangle</td><td></td><td></td><td></td></tr>
<tr><td>Triangle</td><td></td><td></td><td></td></tr>
</table>

Note that:

◦ For the square and the rectangle, the angle of rotation does not pose any problems as it is equal to the complementary internal angle (90°).
◦ Whereas for the equilateral triangle, the learners must use the relation of the sum of the angles of a triangle (180°) to extract the internal angle of the triangle (180° ÷ 3 = 60°), and then the angle of rotation is complementary (180° − 60° = 120°).
◦ At the end of these three examples, the learners arrive at the dual formulas for the geometric construction of the forms in question:
$Ns * \Theta = 360 \rightarrow \Theta = 360 / Ns$
Calculation of Θ for the other forms (pentagon, hexagon and octagon)
◦ Transition to execution (Phase 3: Practical part)</td><td>-</td></tr>
</table>

Table 6.3 continues on the next page→

TABLE 6.3 (cont.): Activities carried out during the experiment.

Computational phase	In this phase, we introduced the notion of variable in LOGO from the first exercise on constructing a square. Then, we asked them to redo the procedures by introducing the variables managing the number of the side of the square Nc, the length of the side of the square Lc and the angle of the rotation Θ to generate a procedure for the construction of the geometric shapes. Variable Nc, Lc, Θ FOR Form X [AV Lc 1 TD Θ1] [AV Lc 2 TD Θ2] [AV Lc 3 TD Θ3] .... [AV Lc n TD Θn] END For shapes of the same side length and rotation angle, learners notice the repetition and the procedure have become simpler: Variable Nc, Lc, Θ FOR Form X REPEAT Nc [AV Lc TD Θ] END Once the procedure is built, in the third phase, the students are invited to translate LOGO	• Use of the ruler, the compass or a half circle. Each learner received a graph paper sheet. • A reminder of the relationship between the number of sides (number of angles) and the value of an internal angle indicated on the white sheet where the constructions were to be carried out: 1. Using only brackets and a graduated ruler, learners were asked to construct the square and rectangle at the 1 cm ↔ 50 cm paper scale and then explain how to proceed 2. Using only a compass or a semicircle and a graduated rule, learners were invited to build forms on the scale of the paper 1 cm ↔ 50 cm and explain how to proceed. The dimensions of the shapes to be built: ◦ A triangle of 200 cm a side ◦ A hexagon of 150 cm a side ◦ An octagon of 100 cm a side
Evaluation phase	• Knowledge test (evaluation) • Perception test	Knowledge test (evaluation)

Source: Authors' own work.

Component 2: Satisfaction questionnaire

In order to get an overview of the motivation for coding and the new method of learning mathematics, we developed a satisfaction questionnaire. Our questionnaire consisted of 20 questions. They aimed to identify learners' attitudes and perceptions:

1. The first three questions (Questions 1–3) provided information on learners' experience with the LOGO environment: We wanted to know whether they had used LOGO elsewhere as well as the number of uses.
2. Questions 4–9 provided information on learners' opinions on coding using the classroom environment.
3. Questions 10–15 provided information on learners' attitudes towards coding.
4. The last questions (Questions 16–20) measured learners' motivation and perception thereof, as well as their perception of coding in the mathematics classroom.

These tests were selected to compare the relevance of our PBL-supporting SDL approach to CT with that of the traditional method.

Results

Result of student assessment (Component 1)

The first part of the Result section illustrates the results obtained from the pre-test and the post-test of both groups (control and experimental groups).

Table 6.4 and Figure 6.2 represent the pre-test results for both the control and experimental group.

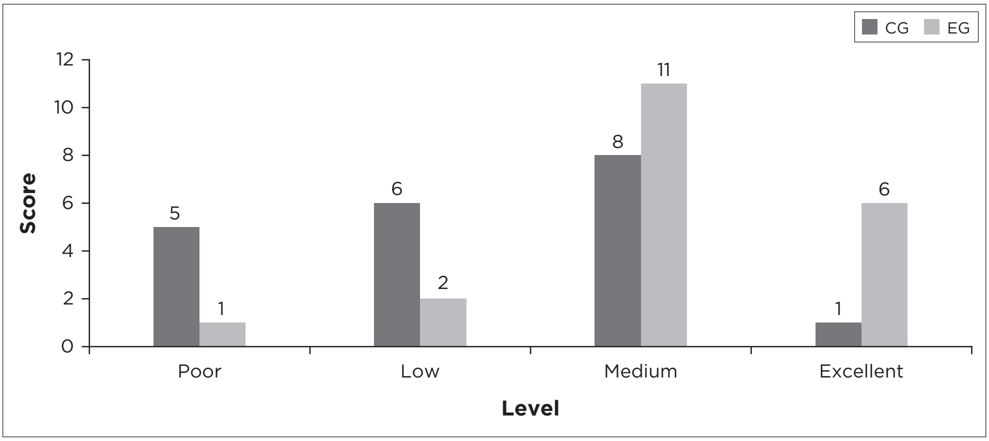
As shown in Figure 6.2, the pre-test results are quite similar in the two groups, which is ascribed to the fact that the groups were created by learners with similar or homogeneous features.

Table 6.5 and Figure 6.3 represent the post-test results for both the control and experimental group.

TABLE 6.4: Pre-test results distributed by level.

Level	Control group (CG)	Experimental group (EG)
Poor	5	1
Low	6	2
Medium	8	11
Excellent	1	6

Source: Authors' own work.



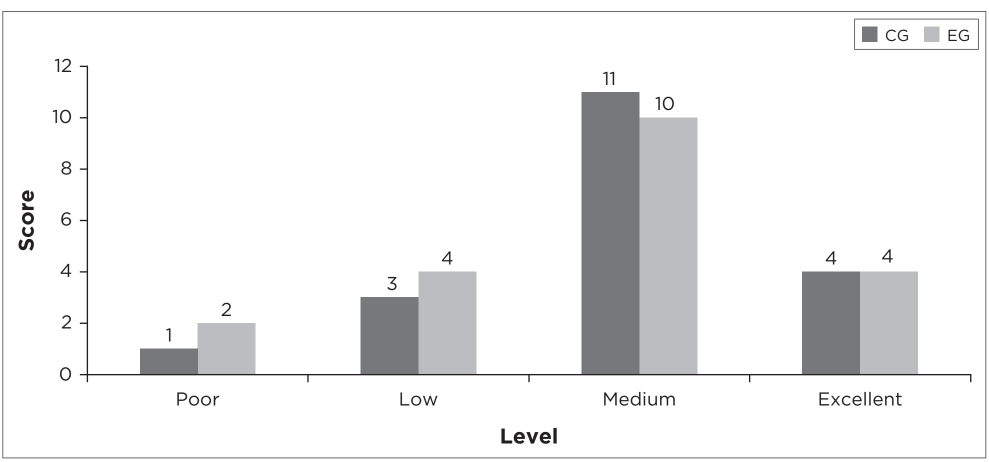
Source: Authors' own work.
Key: CG, control group; EG, experimental group.

FIGURE 6.2: Pre-test learners' level in the control group (left) and the experimental group (right).

TABLE 6.5: Post-test results distributed by level.

Level	Control group (CG)	Experimental group (EG)
Poor	1	2
Low	3	4
Medium	11	10
Excellent	4	4

Source: Authors' own work.



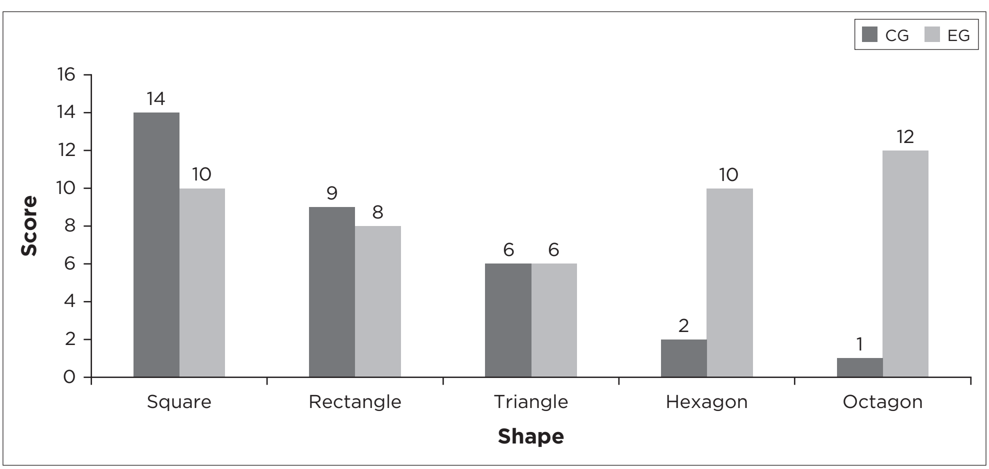
Source: Authors' own work.
Key: CG, control group; EG, experimental group.

FIGURE 6.3: Post-test learners' level of the control group (left) and the experimental group (right).

As is evident from the figure, there is quite a remarkable difference in the noted results of the post-tests, as the average of the experimental group results, which increased by 20.2 and 23.19 points, is greater than that of the control group, which decreased by 1.68 on average, while the number of learners who completed the forms for both groups is presented in Figure 6.4.

As an interpretation, the construction of the square and rectangle does not pose any problems because the angle of rotation does not pose any problems. On the other hand, as regards the triangle, for the control group, the difficulty arose in terms of mastering the rule and the semicircle, whereas the experimental group used the repetition (repeats *n* times) or the forward, reverse and turn commands according to the program history to save time and to provide feedback in the event of an error.

The results also show a significant difference between the behaviours of the experimental and control groups. Also, there was an evolution of geometric abstraction for the experimental group: The results gradually evolved from the square to the octagon, even if the difficulty increased, simply because the learners managed to generalise the computer solution for all the constructions requested by using loops and repetition by noting the relationship (number of repetitions * angle of rotation = 360°) of the first two examples and that the number of repetitions is equal to the number of sides that are similar. Conversely, in the case of the control group, their results decreased successively with the increase in difficulties in constructing the proposed shapes.

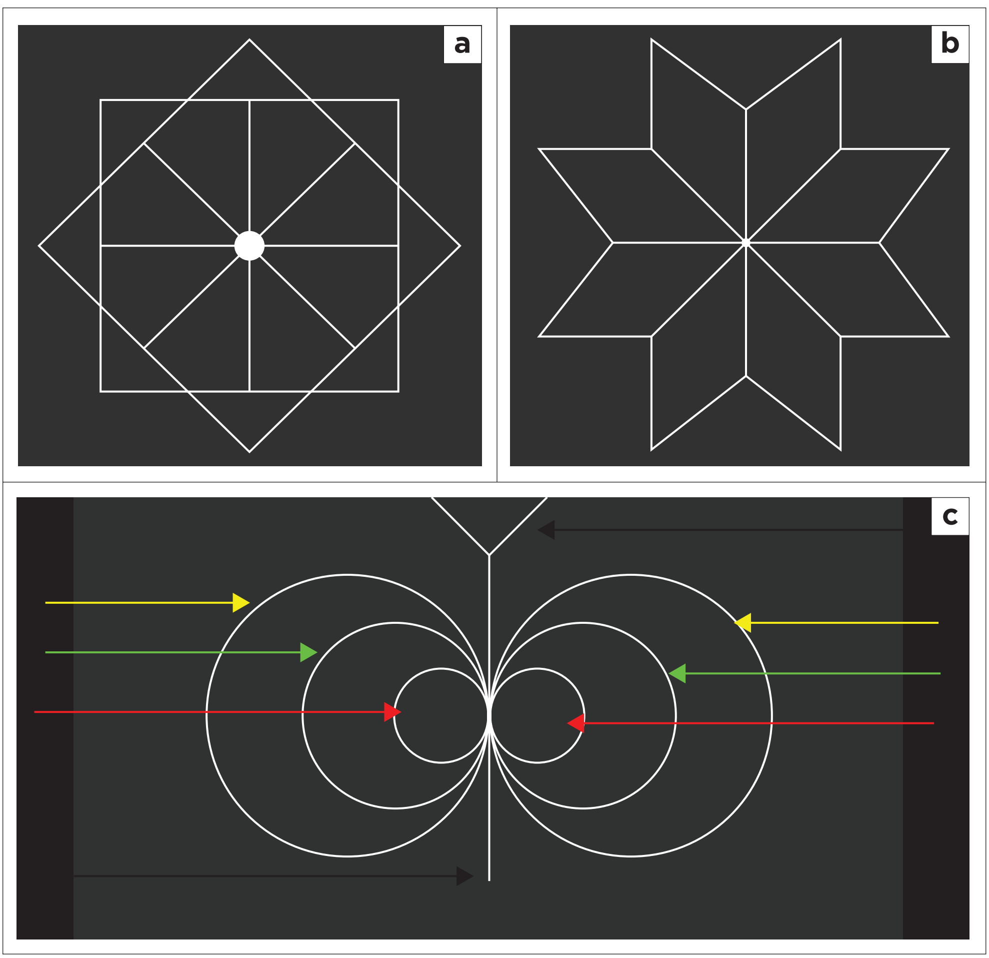


Source: Authors' own work.
Key: CG, control group; EG, experimental group.

FIGURE 6.4: Comparison of the numbers obtained from the constructions of geometric shapes by the traditional method for the control group and through LOGO for the experimental group.

Note that, in the case of the triangle, the two groups were homogeneous. The overall results show that the coding tool increased abstraction and geometric generalisation in learners compared to traditional methods; hence, the development of concrete problem-solving skills in a computer-based manner is considered one of the important objectives of CT.

It should also be noted, as observed, these exercises created in learners the perseverance and challenge to build other more complex forms and to create, innovate and solve mathematical problems differently through algorithms and procedures translated into programs. This is clear in the last exercise of the summative evaluation (post-test), where the main objective was the development of generalisation and abstraction that should be used to draw Forms 1, 2 and 3 (Figures 6.5 a–c).



Source: Images created and exported by the authors, published with appropriate permission from the authors.

FIGURE 6.5 (a–c): Created shapes as part of the activities.

TABLE 6.6: Examples of proposed paths for the different phases of the experimental group (EG).

Form	Stage	Phase 1	Phase 2	Phase 3
Form 1	1	Draw a square	Building the small square	Repeat 4 times, move forward and turn
	2	Draw the central symmetric	Duplicate the small square	Repeat 4 times, move forward or turn
	3	Deviate the rule by 45° and redo Steps 1 and 2	Turn the small square	Repeat 4 times, turn 45° and redo Step 1, then Step 2
Form 2	1	Construct two perpendicular axes of the square (a lozenge)	Build the small lozenge	Repeat 4 times, move forward and turn
	2	Deviate from the 45° rule and redo Step 1	Turn the pattern	Repeat 8 times, move forward or turn
	3	Build a small lozenge	Duplicate the small lozenge	Repeat 8 times, move forward or turn
Form 3	1	Build a small circle on the right	Put the radius R as variable parameter	Repeat 4 times, move forward and turn
	2	Set the direction of the angle rotation Θ as variable parameter	Set the radius R and angle Θ as variable parameter	Repeat 8 times, move forward or turn
	3	Build a triangle at the top	Turn the triangle	Move back *n* steps

Source: Authors' own work.

The parameters are P1–8: R1, R2, R3, D1, D2. The under program for each portion is:

- P1:Repeat360[avR1tg1]
- P2:Repeat360[avR2tg1]
- P3:Repeat360[avR3tg1]
- P4:Repeat360[avR1td1]
- P5:Repeat360[avR2td1]
- P6:Repeat360[avR3td1]
- P7:ReD1Av(2*D1)
- P8:Repeat3[avD2tg120]

Some suggested tracks are noted in Table 6.6.

As an interpretation, the learners in the experimental group accumulated knowledge by pressing on the rotation of angles and sides, or sometimes shapes, as in the case of Form 1 (rotation twice of a square) and Form 2 (rotation eight times of a diamond).

Most learners in the experimental group quickly broke down the forms in question into small, simple forms, duplicated or rotated them. Indeed, in the experimental group, about fifteen learners managed to build Form 1 and Form 2, while only ten learners of the control group realised Form 1 and Form 2. This significant difference confirms what was said earlier.

Result of the questionnaire (Component 2)

The data from the questionnaire show that the majority of learners showed an excellent impression of this environment: eighteen learners of the experimental group and sixteen learners of the control group showed interest in discovering this environment in mathematics. However, the number of learners who confirmed their interest in developing their capacity to work with this coding environment that was used by the experimental group (more than by the control group) was as follows: thirteen learners of the experimental group – two learners used the LOGO environment less than ten times, five learners between ten and 20 times, three learners between 20 and 30 times, and three learners used it more than 40 times. However, seven learners never used this environment elsewhere; so, for the control group, only four learners used this environment less than ten times and in a context other than geometric construction. As regards the attitudes of the experimental group towards the LOGO environment, the majority found coding more effective in teaching geometry than the traditional method. Only two learners were not satisfied. Most learners wished to integrate coding (not necessarily through the LOGO environment) into the teaching of mathematics courses, particularly pertaining to geometric constructions.

Discussion

At the start of this chapter, six research questions were posed. This section considers how these questions were addressed in the research conducted here. Firstly, we explored whether this type of LOGO coding has an influence on the learning of problem-solving in mathematics, especially in geometric construction, and it was found, in line with the literature (Çukurbaşı & Kıyıcı 2017), this approach embracing PBL for SDL has a positive influence on the learning. Furthermore, we probed how problem-solving skills in geometry can be developed using the LOGO coding environment, and it was evident that using this PBL for SDL approach, these skills were developed and the learner responses confirmed this. In addition to this, we wanted to determine how playful LOGO coding can be used as an approach to motivate learners and, as stated, the learners were more motivated and positive to the assessments and the environment through our PBL for SDL approach. Finally, we also explored how playful LOGO coding could contribute to fostering SDL. From the recorded learner perceptions, it was evident that when working collaboratively with peers, the learners could identify their learning needs, choose appropriate resources and strategies, and evaluate their outcomes.

Conclusion

The objective of this research was first to introduce learners to CT in geometry and then to analyse the effect of playful visual coding on the development of geometric thinking in the second year of secondary education through a PBL approach fostering SDL. In our experiment, we compared two homogenous groups at the same level, and statistical tests were applied to both groups.

The discussed results show a statistically significant gain in understanding and improvement in the level of abstraction of learners in the experimental group. It can also be concluded that the development of mathematical thinking using a problem-based approach with the LOGO visual coding environment could allow learners to improve their skills regarding mathematical processes and problem-solving while simultaneously supporting their levels of motivation as self-directed learners. Among the skills studied, we found that abstraction was developed in comparison to the traditional method of mathematics teaching, in this case, particularly by coding. Finally, problem-solving is an improving skill. In this process, the affordances of PBL for SDL were also evident; however, perceptions specifically around SDL were not measured, which was identified as a possible extension of this research. However, aspects of SDL informed the processes followed, and this contributed to the success of the intervention.

Our future research will focus on experimenting with play and visual coding in other environments, such as *Scratch*, to explore its impact on the development of mathematical skills or to generally focus on how coding can improve mathematical thinking in young learners and explore opportunities for effective integration into teaching practices not only related to geometry but also in mathematics and science education.

Chapter 7

A gamification approach to linear equations through creating and solving puzzles in a collaborative learning environment

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Abstract

Linear equations present one of the first instances where learners experience the use of multiple representations. Studies indicate that learners face several challenges when dealing with multiple representations in both moving between various representations of the same phenomena or

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physical situation or interpreting the abstract representation in terms of the concrete phenomena and vice versa. But this also gives us an opportunity to provide the learners with instances rich in multiple representations. This chapter aims to unpack a play-based approach through which puzzles can be used to acquire certain relevant skills and foster self-directedness through this process. Tinkering with the application provides a pedagogical approach which involves 'raw material' to understand and subsequently create the basic problem types generally used in teaching linear equations. This could be achieved by understanding the meaning of and moving from concrete objects to their mathematical algebraic representation in the form of equations. The interactive applications are part of a larger teaching–learning platform used in the schools. Furthermore, the next part of the approach gamifies this aspect of tinkering by allowing a space to ask peers questions in the form of puzzles and solve puzzles posted by the peers. Thus, enabling peer-learning and assessment on a technology-oriented platform. Finally, we discuss cognitive, pedagogical, technological and assessment aspects for such an approach and its challenges.

Introduction

It is clear that solving linear equations may be problematic to learners (Elkjær & Jankvist 2021; Vlassis 2002) and that they often make various errors in this context (Hall 2002). In an attempt to address issues, learners may have in terms of solving linear equations, this chapter proposes the use of interactive activities as a way to learn linear equations through gamification to promote self-directed learning (SDL). This chapter also, therefore, attempts to link up with the scholarship focusing on preparing student teachers to be able to facilitate a context conducive to effective learning and problem-solving concerning linear equations (cf. Casey et al. 2018). Furthermore, this research drew theoretically on not only open education but also elements of gamification and SDL.

The central research aim guiding this research was to look at how the design of interactive activities can potentially aid in learning linear equations using gamification and promote SDL.

Literature review

Mathematics and linear equations

One of the core ideas in mathematics is to use different ways of representing the same information, which has been discussed in mathematics education literature (Arcavi 2003; Goldin 2020; Janvier 1987; Mainali 2021). Seeing the relationship between various representations and operating upon them forms a key competency in learning mathematics (Mainali 2021). Representations can be both internal and external. For example, schemas or mental models are internal representations. While external representations can take various forms, such as verbal (spoken and written), algebraic, tabular, graphical, visual and numerical (Superfine, Canty & Marshall 2009). One can define external representations as 'external mathematical embodiments of ideas and concepts to provide the same information in more than one form' (Ozgun-Koca 1998). A more comprehensive definition of mathematical representations is given by Goldin (2020):

> As most commonly interpreted in education, *mathematical representations* are visible or tangible productions – such as diagrams, number lines, graphs, arrangements of concrete objects or manipulatives, physical models, written words, mathematical expressions, formulas and equations, or depictions on the screen of a computer or calculator – that encode, stand for, or embody mathematical ideas or relationships. (p. 566)

In each of the external representations, mathematical information is encoded, which implies transforming a concept into a sign that can then be decoded to be understood. To successfully understand what the representation contains, the learner has to decode the mathematical information encoded in the representation and operate on it. This is a crucial skill, as mathematical information can occur in different representations. To be able to adapt and use it to solve the problem will be required of learners. Mainali (2021) reviews the importance of various representations in mathematics teaching–learning, particularly visual and graphical representations. Understanding representations can be viewed from perspectives of individual cognition and social practice (Stylianou 2008).

Linear equations present learners in mathematics with one of the first opportunities to work with multiple representations and are an important step in learning algebra (Arcavi 2004). Several studies in mathematics education note the problems that students have with linear equations. For example, see MacGregor and Stacey (1993), Adu-Gyamfi, Bossé and Lynch-Davis (2019), Cañadas, Molina and Del Rio (2018) and Hewitt (2012).

Word problems in mathematics are not recent, and their use dates from antiquity. Some of the earliest word problems date thousands of years ago, inscribed on clay tablets in Babylonian civilisation (Friberg 2008). Also, in the current mathematics curriculum, word problems form an important and integral part of learning mathematics (Verschaffel et al. 2020). However, word problems also pose a great challenge to learners, where abstract mathematical representations are in the form of words, and the learners have to assign mathematical meaning to the words and then perform operations on them to get a solution. In their comprehensive survey on mathematical word problems, Verschaffel et al.'s (2020, p. 1) remark about the word problems summarises this well: 'Word problems are among the most difficult kinds of problems that mathematics learners encounter'. But what constitutes a word problem? According to Verschaffel et al. (2000) (as quoted in Verschaffel et al. 2020), this concept can be described as:

> Word problems are typically defined as verbal descriptions of problem situations, presented within a scholastic setting, wherein one or more questions are raised the answer to which can be obtained by the application of mathematical operations to numerical data available in the problem statement or on numerical data derived from them. (p. 1)

Word problems also form a large section of books on recreational mathematics. For example, books by Yakov Perelman and Martin Gardner feature several word problems which are challenging to solve (e.g. see Perelman 1957, 1979; Gardner 1981, 1986). But word problems come with unique challenges (Clement 1982) and are prone to misconceptions in interpretations and difficulties (Elkjær & Jankvist 2021; Pawley et al. 2005).

In the case of linear equations, typical word problems involve presenting a situation containing encoded mathematical information required to solve the problem. For example, a typical problem involving guessing a number is: I am thinking of a two-digit number that is larger than 50 dividable (÷) by 4, 6 and 9. What number am I thinking of? There are several variations on this theme, and several problems can be constructed using the same number. We discuss this further in the context of the design of the activities.

As noted, the movement between mathematical representations presents a challenge to the learners. We are trying to solve this problem of movement between representations via this design of open mathematical interactive activities using externalised memory and gamification. As the activities are published openly, the idea of open educational resources (OERs) is also highly relevant to this work.

Self-directed learning

In the process of learning about linear equations by means of games, it is also essential to support the self-directedness of learners. Consequently, the concept of SDL was relevant to this research. One of the most used definitions of SDL is by Knowles (1975, p. 18) as defined in Chapter 1, in which he looks at various facets such as taking the initiative, learning needs, learning goals, resources and learning strategies.

Research has shown how a gamification strategy, specifically in the online context, can support learner SDL in a very positive manner

(Palaniappan & Noor 2022). Importantly, for the sake of SDL, a gamification approach should involve frequent and quick feedback, have a balance of game elements for critical thinking, include choices for self-management and have reward structures supporting motivation (Lindberg 2019).

Furthermore, the intersections between SDL and OERs have been established in the literature (Olivier 2021), as access to resources and selecting appropriate resources are key to effective SDL. In this context, OERs are briefly discussed.

Open educational resources

An important part of the proposed intervention in this chapter is using an openly-licensed resource. Consequently, it is recommended that an OER is used. The concept of OERs is defined by UNESCO (2019):

> [...] learning, teaching and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others. (p. 5)

This approach implies that the resource proposed in this research can be reused and, more importantly, be localised for any other context and curriculum. From the scholarship of OERs and open education, there have been earlier examples of how open resources could be used effectively in supporting gamification (García-Holgado et al. 2020; Kokkinaki, Christoforos & Melanthiou 2015). Within this context, using OERs is recommended because they can not only be free but may also be adapted (Chen 2018).

It is important to note that specifically integrating OERs in the learning process for the sake of gamification is considered a complex task, especially in aligning the learning outcomes and purpose of the resource (Kokkinaki et al. 2015). This concept was explored further as gamification frames how learning was approached in this research.

Gamification

As this chapter attempts to explore the design of interactive activities that can potentially aid in learning linear equations by use of gamification and promote SDL, a discussion on the recent scientific literature is pertinent to understand the nature of gamification. There has been a surge in interest in gamification in academia and research in recent years (Sailer & Homner 2020). Despite the fact that we may not be aware of it, it is presently pervasive in our everyday lives (Dias 2017). Game design features may be employed in non-game situations according to various definitions in academic literature. It has been implemented in a variety of disciplines, such as commerce, employment, health and environmental studies (Behl et al. 2020; Larson 2020; Robson et al. 2016; Sardi, Idri & Fernández-Alemán 2017), as well as the educational sector (Faiella & Ricciardi 2015).

Elements of gamification

In order to increase students' interest in their work and boost their extrinsic and intrinsic motivation, one method that has proven effective is gamification (Buckley & Doyle 2016). In contrast to extrinsic motivation, which is driven by the pursuit of reinforcement, the term 'intrinsic' refers to the completion of an action for its own sake rather than for the sake of any external gain (Fischer, Malycha & Schafmann 2019). Finding the underlying motivations that will keep people engaged is crucial when designing gamification strategies. Connectedness with others (the feeling of interdependence), competence (the feeling of being able to complete tasks and the ability to execute a task to a certain level) and autonomy (the extent to which an individual's actions are motivated by their own interests) are the three psychological needs central to self-determination theory (SDT) (Deci & Ryan 2016; Trigueros et al. 2019). For SDL and SDT to provide engaging gamification, players must feel independent, in command of their own actions and capable of accomplishing the game's goals (De-Marcos, Garcia-Cabot & Garcia-Lopez 2017). Considering the various types of players is essential for the success of gamification that aims to achieve this goal. Marczewski (2015) used the acronym RAMP (relatedness, autonomy, mastery and purpose) to summarise the four main sources of intrinsic motivation: *A sense of belonging*, *control*, *competence* and *significance*. Gamification goes beyond the traditional uses of game mechanics such as points, badges and leaderboards by using the underlying concepts of game design. Most studied is the mechanics, dynamics and aesthetics (MDE) method proposed by Hunicke, LeBlanc and Zubek (2004). Game designers use the MDE model to provide a bridge between the game's rules mechanics, game dynamics and attractive aesthetics. To further dissect the gamification, consider the following:

- **Mechanics:** Action and control methods available to players in the framework of a game are called mechanics. For example, you can select decks, gamble, barter, attack, compete and collaborate.
- **Dynamics:** When the mechanics are being implemented, dynamic behaviour is what is supposed to happen. For example, consider socialising, bluffing, reflecting, status and attention.
- **Aesthetics:** When a player interacts with the game system, the system elicits positive emotional reactions from them, which we call aesthetics. In addition to sensation, fantasy, story, challenge and camaraderie, exploration, expression and amusement are some of the sub-categories (Hunicke et al. 2004).

Using gamification to improve learners' motivation and academic performance

In the classroom, students are more likely to participate if the game components employed in gamification have clearly defined goals and incentives. As per the research by Beemer et al. (2019), only 15% of learners who participated in gamification did not frequently engage in physical activity, with statistically significant changes compared to the standard instruction group, for example, in physical education. For low-income educational facilities, more tactics and more time spent participating in breaks between programmes would be essential for better outcomes.

Gamification with quick incentives (points and badges) and a story background may be mainly helpful among pupils with poor motivation (Fernández-Rio et al. 2020). A study found that in university education, gamification increases student engagement and involvement, which leads to an improvement in academic achievement (Castañeda-Vázquez et al. 2019). As a result, gamification in education with the purpose of fostering healthy habits leads to a more active and positive school environment where students may get some exercise and have a good time.

It has been proven that gamification may also increase learners' participation and learning in scientific disciplines (Díez, Bañeres & Serra 2017; Tsai, Lin & Liu 2020). Student participation in the learning process is a key factor in this study's findings, as is the fact that students are able to perform the ongoing practice of their academic curriculum through game mechanics and continuous feedback, which provides clues and prospects for reflection when they encounter difficulties. Peer interactions, web blogs, challenges and prizes are used in the e-learning higher education institutional (HEI) setting to encourage involvement and dedication (Garcia-Cabot et al. 2020). Writers are able to describe it because there is a happy medium between the level of difficulty and the students' abilities; this balance between complexity and their capabilities encourages students to persist and succeed throughout the course. (Fernández-Rio et al. 2020). Students' commitment to the course and learning may suffer if gamification elements like points, badges and leaderboards just reward behaviours with rewards in response to extrinsic motivation (Kyewski & Krämer 2018).

Educational gamification, which incorporates foundations of science, technology, engineering, art and mathematics (STEAM), may effectively teach elementary school learners environmental stewardship. The goal of gamification, according to one definition (Nurmi et al. 2020), is to promote the development of certain habits, such as persistence and accuracy; therefore, it may be used to encourage students to engage in sustainable practices and civic competency in a fun and engaging manner

(Sipone et al. 2019). Students' interest and engagement may have been boosted by using game components, which positively impact their civic mindset and respect for the natural environment (Gatti, Ulrich & Seele 2019). With those mentioned earlier, it is clear that using information and communication technologies (ICTs) in a fun manner to study may help increase student involvement, motivation and achievement in social and civic essential skills in higher education (HE) (Campillo-Ferrer, Miralles-Martínez & Sánchez-Ibáñez 2020).

The previous section highlighted why gamification is such a significant field of study in education. However, an SDL component is crucial to truly gaining the most from this approach, especially in an online or multimodal gamification approach.

Gamification and self-directed learning

The work of Zap and Code (2009) discusses various theories of SDL, including learner self-efficacy, learner self-determination, motivation, interest, intention, aptitude, goal and task orientation, self-awareness and metacognition, in the context of a review of the literature on SDL in game environments. The qualities of an authentic learning environment were also investigated. Firstly, similar to the elements of gaming settings that encouraged SDL, this includes imitating a real-world situation in which students make choices in a safe setting with no consequences. Secondly, students practise their newly acquired transferable abilities by engaging in authentic activities inside a virtual environment. Thirdly, learners learn via gamification by seeing and modelling the world around them. As a result, students have taken on a wide range of roles in investigating and developing new ideas. In contrast to their theoretical model, another research project used a grounded theory approach to extract the many SDL processes from video games and gamification approaches (Toh 2018). Research methods such as interviews and the think-aloud technique were also utilised to determine whether aspects of game design promote player agency in video game contexts (Toh 2018).

Methodology

Research design, data collection and analysis

The research has a philosophical stance consistent with interpretivism. In qualitative research, the interpretative philosophical perspective is focused on meaning and aims to comprehend society members' definitions and understandings of events to provide light on how a certain group of individuals makes sense of a given situation or phenomenon (Maree 2020). In understanding the interpretive perspectives, the SDL of linear equations by creating and solving puzzles, which imply play-based problems in this chapter, will be investigated in a collaborative learning environment.

This study will use a qualitative methodology. According to Creswell and Plano Clark (2018), a qualitative design is one in which knowledge claims are made by the researcher largely on the basis of constructivist theories (i.e. pursuing a hypothesis or pattern by considering the many interpretations people have given to their experiences, both privately and collectively, across time). According to Maree (2020), a qualitative design seeks to gather detailed, descriptive information about a phenomenon or situation to comprehend it better. In our analysis, we opted to sample subjects at random. As part of a larger course on linear equations, the sample included these three interactives and the data they produced. In this chapter, 'interactive' refers to any digitally manipulable object that may be used for instruction. The study tries to describe aspects of interactives and their consequences for pedagogical procedures.

Regarding data analysis, the phrase content analysis may be roughly described as 'systematic data coding based on specified themes or categories' (Cohen, Manion & Morrison 2018, p. 704; Fraenkel et al. 2012, p. 478). It is possible to apply content analysis in both practical and theoretical research. Counting and classifying words in a measuring instrument or determining the frequency of themes via document analysis are two prominent examples. In a mathematics class, a researcher examines how gamification affects students' academic performance.

Artefact analysis is the method used to define the study of artefacts. A simple definition of artefact analysis is that it views artefacts as the results of human activity. To understand artefacts, it is necessary to understand the social context in which they are made and used (Bechky 2008; Schubert 2014). As previously said, this study focuses on 'artefacts' in the strictest sense, that is, tangible items, structures and physical layout. Artefacts abound in organisations. Therefore, data creation on artefacts is not concerned with producing new data but rather with selecting artefacts that meet the study objective. An artefact's possible linkage to one or more aspects of innovation, that is 'ideas', 'outcomes', 'people' and 'transactions', is the end direction of this study design that tries to understand the implementation of gamification in the classroom. There are many examples of artefacts. Firstly, it is also worth noting that some artefacts are regularly employed in the innovation environment. Secondly, researchers may use artefact analysis to apply to broader concepts. Choosing artefacts that each organisation's unique actors think are significant for decision-making and communication in general and innovation in particular is one concept. In terms of the organisation's public image, identifying long-standing artefacts that have played a significant role in the organisation's everyday operations is another key element (Froschauer 2009).

The learning context

The three interactives presented here are designed to provide the students with externalised memory where they can interact with the application to create new instances of the problems. The interactives can be classified as virtual manipulatives, defined as 'digital artefacts that resemble physical objects and can be manipulated, usually with a mouse, in a similar way as their authentic, concrete counterparts' (Bartolini & Martignone 2020, p. 487). The interactives also provide a 'board' where the students can save the manipulations and calculations done in the context of forming the puzzles. Each interactive provides different types of essential data which can be used in forming and solving the puzzles.

The modules and units in which they appear are OERs released with Creative Commons (CC) BY license. This means they can be accessed online and can also be downloaded for offline use. Initially, they were part of a specially designed learning management system (LMS) platform to work on schools' local area network (LAN). Discussion on the features of the platform that help in gaming aspects is done in a later section in this chapter, titled 'Gamification via the platform'.

The first interactive is based on coins and their monetary values. The presence of coins of different denominations presents us with many natural opportunities to form puzzles. The number of coins and their denominations form the two parameters which are helpful in this activity. The interactive designed to help in this activity allows the learner to change these two parameters independently.

Coins

The first context uses the different monetary coins to form puzzles, as shown in Figure 7.1. In this case, the students can use information about the number of coins and their monetary values for solving and forming puzzles. In this section, Rs. (or ₹) refers to Indian rupees.

The learner enters the different number of coins (denominations of Rs. 1, Rs. 2, Rs. 5 and Rs. 10), the total amount and total number of coins are calculated, and the results are written to the board. The interface shown below allows the learners to change the denominations of the coins. Clicking twice on the denomination of a coin will change the coin denomination. Once the coins are chosen, the learners can change the number of coins by typing the required number using input boxes. This action readily calculates the following:

1. Total amount of money in coins.
2. Total number of coins.

For example, in Figure 7.1, we have six coins of ₹1 and 5 coins ₹2. This information is used to calculate and display the total amount equal to ₹16 and the total number of coins eleven. Once this information is generated, the student can write this information to the board. Depending on what information is hidden and what is given in a puzzle, different types of problems can emerge. For example, if the total amount (money) of coins is not given, but other information is given, then the problem can be to find the total amount that is present. In the other case, if the total amount is given with some denominations, the total number of coins or coins of any particular denomination can be found out. Starting from straightforward puzzles, the puzzles can become complicated, requiring several steps to solve. From the same set of data, several puzzles can be generated, depending on what is hidden. Though it might seem trivial, developing

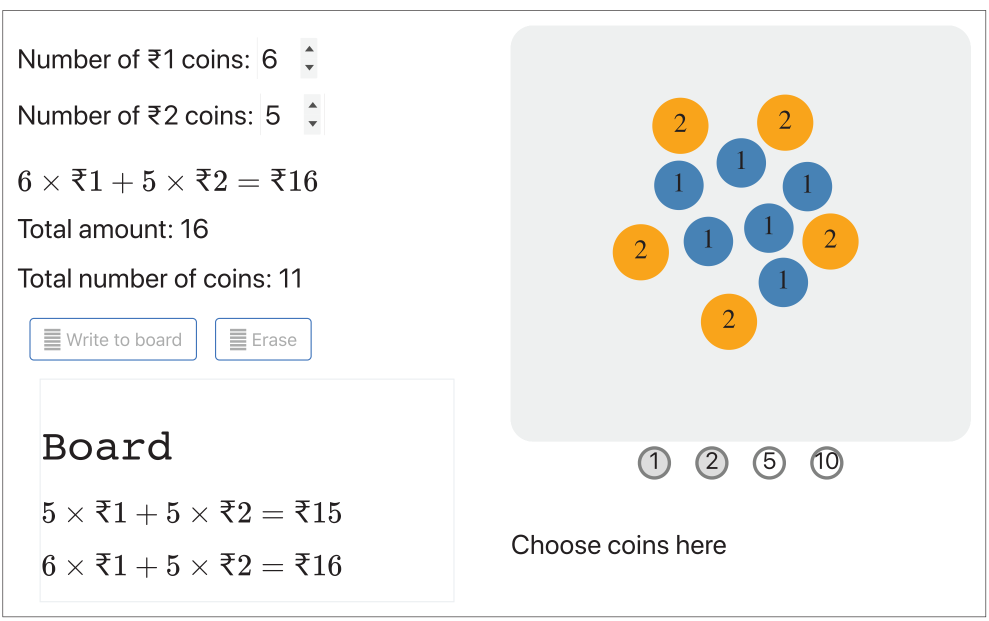

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FIGURE 7.1: The interface for the coins interactive.

puzzles is a cognitively challenging task. Hiding too much information can lead to unsolvable puzzles. But to create a solvable word puzzle, the learners must solve it themselves.

At the same time, the learners can also use some interactive elements to solve the puzzles. They can add the partial data to see what type of equations result from that as an aid to solving the puzzles.

☐ Ages

The second interactive involves forming puzzles with ages. Puzzles with the ages of various people are quite common. They typically involve providing the sums and differences in the ages or the ages of the smallest or largest individual in the sample. In the interactive tool shown below, the learner can enter the ages of the individuals in the sample by numbers in the input box. Once the ages are entered by clicking on the 'Calculate' button, the interactive finds and gives information regarding the data entered. This information includes:

1. Age of the youngest person.
2. Age of the oldest person.
3. Difference between the largest and the smallest ages.
4. Sum of all ages.

The user enters the ages of the four persons, and the interactive, as shown in Figure 7.2, computes some of the common data used in creating puzzles based on ages.

Using the information calculated from the data entered, various puzzles can be formed.

If the learner changes the values of clicks on calculate. The new calculated values are stored in the board as in the previous activity. Thus, the learner can experiment with a large number of values to create puzzles from them.

☐ Number

The number puzzles perhaps form the most common puzzles found and allow for the most flexibility for the puzzle creators among the three interactives considered here.

In the example in Figure 7.3, the number '65' is factorised by various other numbers as selected by the user, and the result is written on the board.

The next interactive uses integers and their factorisation to form puzzles. The core mathematical idea used in this activity is that a given number can be represented in many ways. The four basic operations of arithmetic,

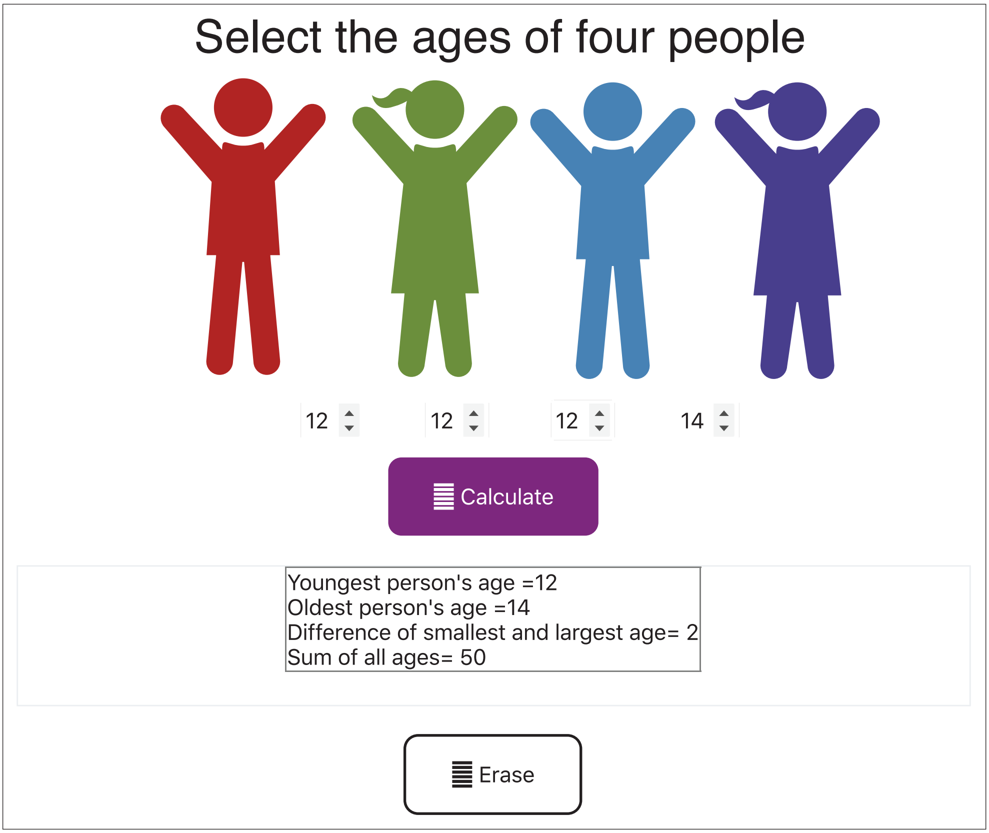

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FIGURE 7.2: The interface for the age interactive.

namely, addition, subtraction, multiplication and division, allow us to represent a given number as a combination of others. This interactive helps the learners to achieve or visualise exactly this. A learner can input a given number in the text input box. In the next step, the learners click on any one number 1 through 10 to find out the factors of the given number with these numbers.

☐ How the interactives are to be used by the learners

The learners were provided with a demonstration of the interactives and their features. After this, they were allowed to explore the interactives by repeating the given examples. In the second step, they were asked to create linear equations which could be solved for each of the three interactives. Finally, they were asked to create puzzles based on the linear equations that they had created with help from the interactives.

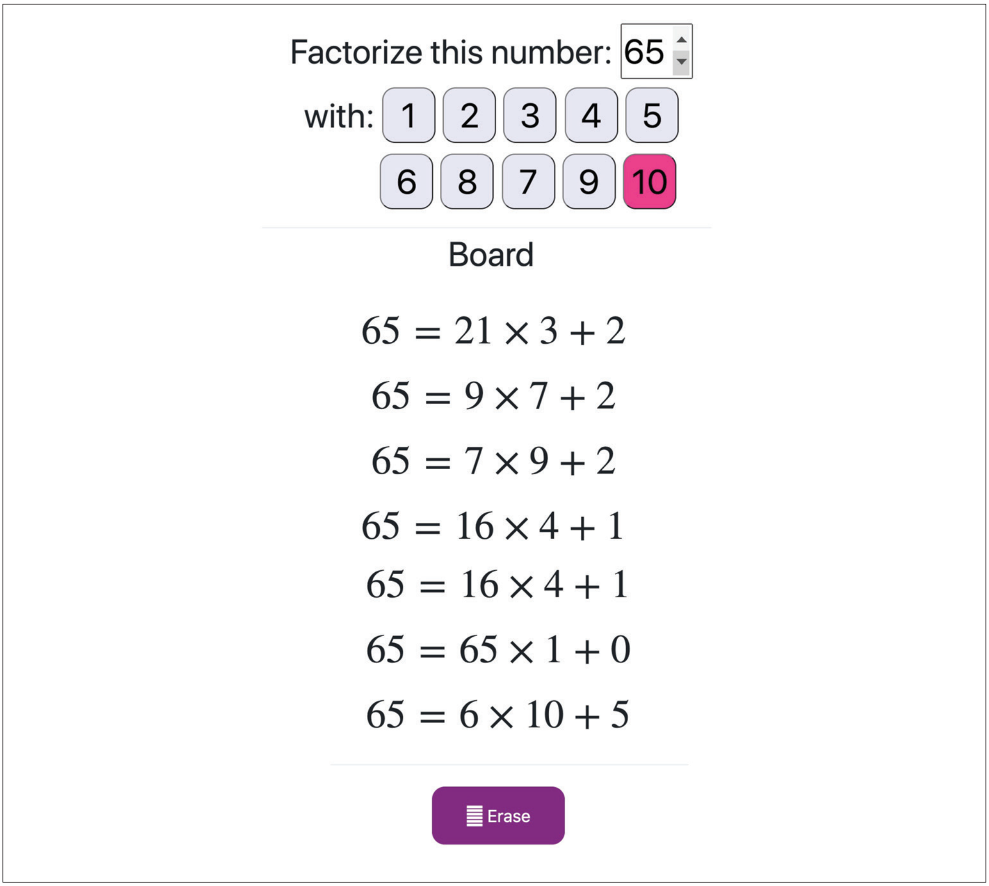

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FIGURE 7.3: Interface of the number puzzle interactive.

Design aspects of the interactives

In this section, we consider some of the design aspects of the interactives and how they address some of the problems that learners face.

Manipulatives and multiple representations

The interactives noted before use concrete visual images for the different contexts. In addition, when the learner inputs the parameters in the form of numbers, the interactives present the learners with information in mathematical form, sometimes with operations on them. For example, the total age of persons, the total amount of coins or the result of the factorisation of a number. These expanded mathematical representations are a mix of verbal, algebraic and numerical formats that the learners need to understand to form linear equation puzzles. The movement between these representations and operations on them enables a mathematical understanding of the concept. The simple action of learners changing the parameters, for example, the number of coins of a given denomination, gives an immediate change in the following representations, thus scaffolding the movement between representations.

Scaffolding – externalisation of memory

During the design of the interactives, one of the key problems that was kept in mind was aiding the movement between various mathematical representations. The visual picture of the interactive helped with this. We tried to keep the interactives as simple as possible, and the output of the interactives was provided separately on a place called the 'board'. A board is a digital space where just like the blackboard in the classroom, one can write information to be accessed later. The information on the board can store multiple entries from the interactives. Each of the interactives has a board where the learners can store the information which is generated during working with the interactives. This information can then be used for creating puzzles. If the learners feel that the board is too full, they can erase the board for a new start. Similarly, the learners can also use the board to solve the puzzles by using the interactive to input the information. Thus, the board is a dynamic personal external memory bank of the learner. We use the word dynamic as it is changed with the input, and the learners can see these changes happening. For example, in the number interactive, as soon as the factoring number is clicked, the interactive shows the decomposition of the input number. Thus, the learner can access all this information via the board. When the information on the board is not needed, or it is too crowded, it can be erased by the learners, and new information can be added. The learners can also copy this information to a notebook for access later.

Self-directedness

The three interactives presented the previous three sections have strong elements of self-directedness as they enable the learners to explore mathematical space safely. The ability to tinker and explore mathematical objects in the form of coins, ages of persons or numbers and immediately view and store (on board) the resulting mathematical information and representations can allow learners to design and create their own examples to learn. These manipulatives can also generate different and a great variety of combinations of the parameters so that the learners can vastly expand their problem space.

Francom (2010, pp. 10–11) proposes four guidelines to foster SDL in learners. They include:

1. Matching the level of SDL learning required to student readiness.
2. Progressing from educator to student direction of learning over time.
3. Supporting the acquisition of subject matter knowledge and student self-directedness together.
4. Having students practise SDL in the context of learning tasks.

In the context of this chapter, the three interactives and the associated tasks can be used according to the level of the students. The difficulty of linear equation word problems via puzzles created and solved can indicate the level of students. This can vary greatly, from simple questions to complicated word problems as allowed by the imposed conditions. As soon as the teacher introduces the interactives in the classroom, a little hand-holding will be involved to understand the interactives' basic mechanics. Once the learners become aware of how the interactives work, they can be on their own, especially when it comes to posting and solving puzzles. The creation of valid puzzles in the form of word problems on linear equations has an implicit understanding of the mathematics involved. This is where the learners would display their own knowledge with problem-creating and problem-solving skills. This part of the activity would indicate a progression from teacher- to learner-orientation of learning. As discussed earlier, the interactives support the movement between mathematical representations, which is the subject matter knowledge in this case. It is done in a manner that involves a lot of student agency and autonomy. Finally, the fourth guideline is realised in the practice of posting and solving puzzles (the learning task). Thus, we see that several desiderata for fostering SDL can be seen in the interactives and associated activities. Of course, a lot will also depend on how the teacher in the classroom introduces and implements the unit.

In their synthesis of different SDL models, Bosch, Mentz and Goede (2019, p. 18) recognise three components of SDL for the learning situation. These three components are opportunity, support and collaboration. We now discuss how these components are part of the interactives:

- **Opportunity:** The interactives provide almost limitless opportunities for students to explore the mathematical space by allowing them to control the interactives and the data generated from them.
- **Support:** According to the design of the activity, the teacher introduces the interactives to the learners and then allows them to explore by themselves. The culmination of this process of exploring is the formation and posting of word problems in the form of puzzles. Support is available on the platform for operating the interactives in

the form of animated graphics interchange formats (GIFs), which can also be used in SDL.

- **Collaboration:** The activities around the interactives were designed keeping in mind that there will be a group of two–four learners working on a computer in the school. This approach means there will be enough circumstances for intra-group collaborative learning between learners working at the same computer (Dhakulkar & Nagarjuna 2018). Working with other peers via the digital space of the platform can also provide opportunities for inter-group collaboration. Such collaboration supported by the use of computers has been termed computer-supported collaborative learning (CSCL) (eds. Cress et al. 2021, p. 122) and has been extensively studied.

Similarly, Bosch et al. (2019) also present three components of learning: motivation, context and cognition. We consider how these three components are realised in the interactives and associated activities.

- **Motivation:** From one of the author's (Dhakulkar, Shaikh & Nagarjuna 2017) experience working with learners, one thing that stands out is the lack of avenues for learners to interact and share their knowledge in the classroom. The design of the activity explicitly involved gamification for sharing knowledge. The gamification motivates the learners to ask for puzzles from peers and solve them. This act of creating puzzles and sharing them in a public space can be a great motivator for learners.
- **Context:** Once the gamification process starts, the learners take control of the teaching–learning process, as it involves peer-learning and peer-assessment, with minimal intervention from the teacher. The classroom processes are shifted to the shared digital space on the platform.
- **Cognition:** The interactives help the learners via the process of cognitive offloading by externalising the relevant data on the 'boards' where the relevant information is easily accessible. This process can help the learners to focus on comprehending the mathematical meaning embedded in different representations in the interactives. This process is complete when they can form word problems in the form of puzzles for their peers, and when they can decipher the mathematical meaning in the puzzles posed for them to solve.

Gamification via the platform

Using gamification for continuous learning and SDL in HEIs, another study found that students who learnt through online gamification showed better results in their knowledge of sustainability, pro-environmental attitudes and achievement than students who learnt through traditional methods. According to the students who participated in this study, their motivation was based on recognition, competence and the sensation of belonging to a larger community (Mahmud, Husnin & Tuan Soh 2020).

Though the three interactives can be run as standalone instances, their value is much enhanced when they are used inside the specially designed platform.

One of the major challenges of working in government schools in India is the limited infrastructure in the form of accessibility to computing devices and Internet connection. To overcome this challenge, a student platform (CLIx Platform 1.0, TISS, 2018) was designed as a part of the larger project: Connected Learning Initiative (CLIx).[3] The student platform has innovative features that help us use the challenging infrastructure conditions to the fullest. The student platform is both a LMS as well as a content management system (CMS) and works on the LAN in the school lab. As the platform works via a 'school server' present in the school LAN, this design feature removes the dependency on the Internet and simultaneously gives the learners an Internet-like experience.

Each learner is given an individual anonymised login (for example, yellow-rabbit-xx, where 'xx' denotes school code) to the platform and can add other peers for a session via a buddy-login feature. The project was designed in such a way that three students worked on one computer during the sessions. This arrangement allows us to maximise the utility of the infrastructure in the schools in addition to providing space for inter- and intra-group collaborative learning (Dhakulkar & Nagarjuna 2018).

The platform allows the students access to the module's resources which include the instructions and help material in the form of animated moving images in a graphic interchange format (GIF) and downloadable *GeoGebra* (*GeoGebra Classic* 6.0.7, Markus Hohenwarter et al. 2022) files. Pre and post-test assessment items are included before and at the module's start and end. Each unit in the module has its own assessment items. The platform also allows the students to upload the media files that they have created, which are accessible to other peers. Each file and activity allow for comments and responses to be taken from the learner. This creates a space for discussion of activities in an explicit manner. The teacher can intervene in the discussions on the platform when required. The platform also creates a digital portfolio for the learners to record their actions on the platform. Thus, the learners can view their own learning over time and interact with their peers. Therefore, there are three major areas in which the platform's

3. See https://clixplatform.tiss.edu/ and https://mat.geogebra.org/classic.

design helps the learners: SDL, peer-learning and peer-assessment via gamification.

We have discussed the SDL aspect in the context of the activities. We will now discuss peer-learning and assessment via gamification in the platform next. The basic idea is that once the learners are comfortable playing on the apps, they get to create 'puzzles' for other learners on the platform. They take help from the applications to create these puzzles and then post them on the platform via 'Comments' at the bottom of the activity page. These comments are immediately broadcast, and other learners can see these comments and attempt to solve these puzzles and post the answers to these via the 'Reply' option to the posted comment. They can take help from the apps to solve these puzzles. The original poster who posted the puzzle then checks for the correctness of the puzzle and replies to the answers indicating whether it is correct or not. Each learner or group of learners thus can create and solve several puzzles based on each app. Also, as the puzzles and their answers are always visible after being posted, the teachers can check and intervene if necessary. But this aspect is secondary. What the platform allows is for gaming the aspect of puzzle solving with the platform's help, thus making peer-learning and peer-assessment possible.

Examples of use: Gamification of linear equations

The features of the platform were described before making it amenable to introducing elements of gaming during the learning process. Sharing ideas and artefacts and interacting via comments in contexts of these makes the platform an enriching, safe space for learners. For the three activities under discussion, gamification happens via the creation of puzzles by the learners. These puzzles, created with the help of the data from the interactive applications, are posted on the platform at the bottom of the page as comments. We discuss two examples of how such puzzles will be posted and subsequently answered.

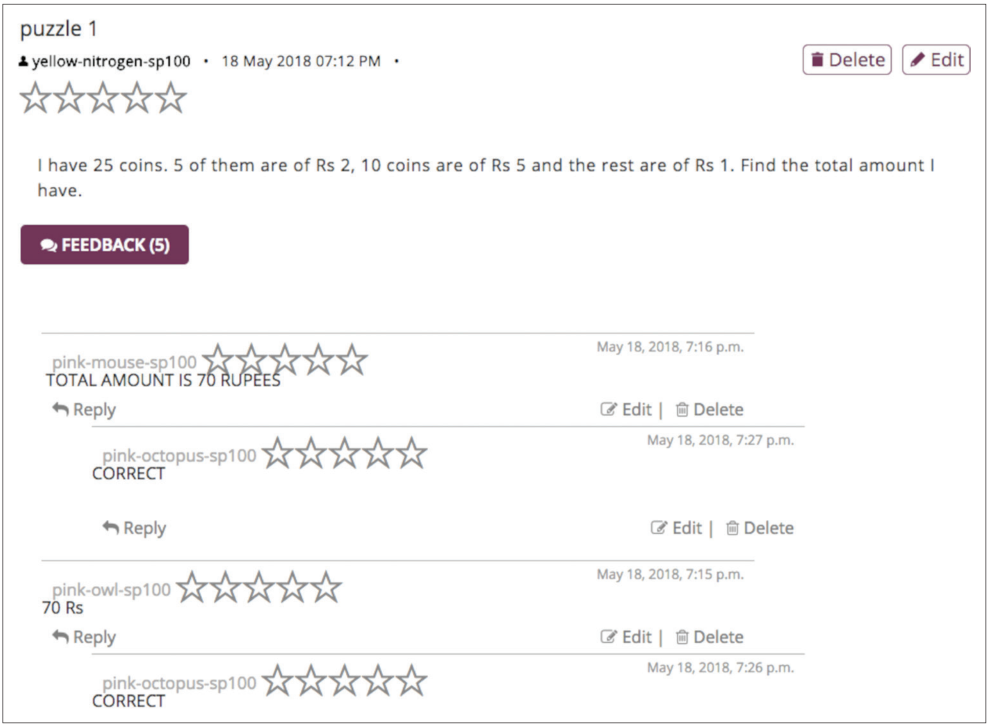
Example 1

Example 1 shown in Figure 7.4 is a puzzle based on coins and uses the data from the interactive coin application discussed in the earlier section titled 'Coins'. The puzzle by 'yellow-nitrogen' reads:

> 'I have 25 coins, 5 of them are ₹2, 10 coins are ₹5, and the rest are ₹1.Find the total amount I have.'

In this case, the algebraic equivalent of this situation is:

$$T = 2 \times 5 + 5 \times 10 + 1 \times X. \qquad \text{[Eqn 7.1]}$$



Source: Screenshot taken from the student platform and exported by the authors, published with appropriate permission from the authors and institution.

FIGURE 7.4: Example 1, a coin puzzle in which the total value of coins is to be calculated.

where T is the total amount and X is the number of ₹1 coins. First, the puzzle solver has to find the number of ₹1 coins X. For this, the total number of coins is given and the number of ₹5 and ₹2 coins are given. Hence, if the number of ₹1 coin is X, then:

$$25 = 5 + 10 + X, \text{ therefore } X = 25 - 5 - 10 = 10. \qquad \text{[Eqn 7.2]}$$

Then using the equation for T, the solution is:

$$T = 2 \times 5 + 5 \times 10 + 1 \times 10 = 10 + 50 + 10 = 70. \qquad \text{[Eqn 7.3]}$$

For this puzzle, two users, ‘pink-mouse’ and ‘pink-owl’, give answers checked by another user ‘pink-octopus’. This puzzle asks for only one of the denominations, though the peers have given answers for both.

☐ *Example 2*

Another example of a coin puzzle is shown in Figure 7.5. In this example, the puzzle reads [verbatim response given below]:

> ‘I have Rs. 29 with me. The total number of coins is ten. There are *n* two denominations [*sic*]. I have 7 coins of [...] Now solve this problem.’

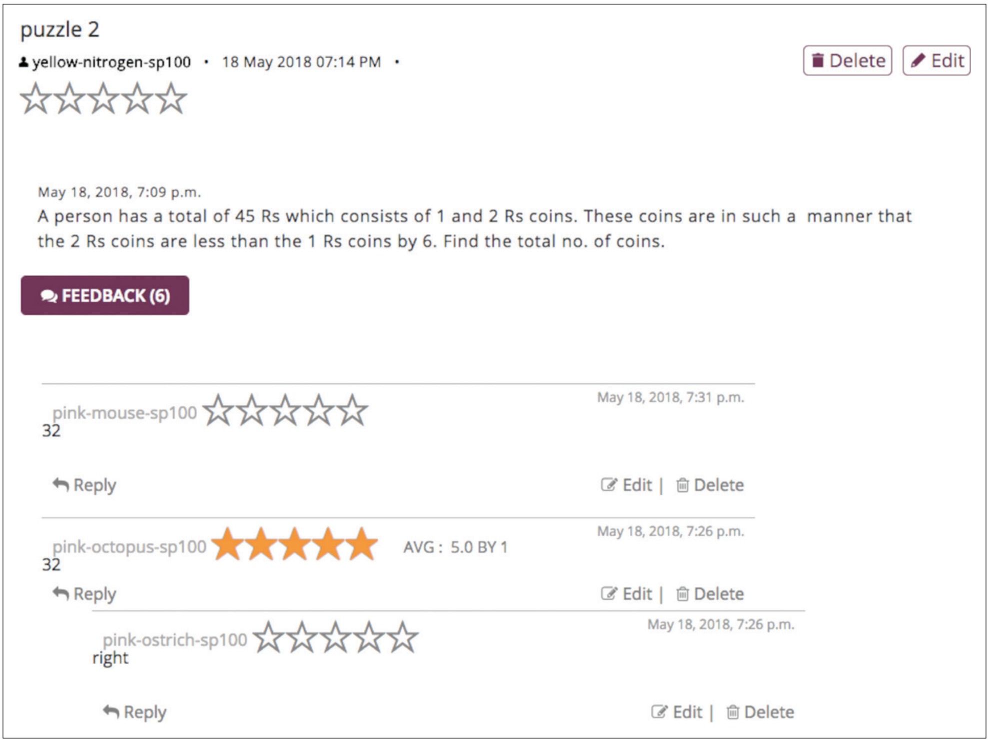


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FIGURE 7.5: Example 2, a puzzle based on finding the total amount of coins.

In this case, the algebraic equivalent of this situation can be obtained as such: The total amount of currency is ₹29. We are given that there are a total of ten coins and two denominations of the coins; let *X* and *Y* be the number of coins in the two denominations.

Hence:

$X + Y = 10$

Or:

$Y = X - 10$ [Eqn 7.4]

And coins of one denomination are seven in number. Hence, either $X = 7$ and $Y = 3$ or $X = 3$ and $Y = 7$. Hence our equation becomes:

$nX + mY = 29$

Or:

$3n + 7m = 29$ [Eqn 7.5]

The interactive instance that was used to generate this data can be seen in Figure 7.6.

Now this equation cannot be solved with just given information. So we use other information that is available to us: the denominations of the coins.

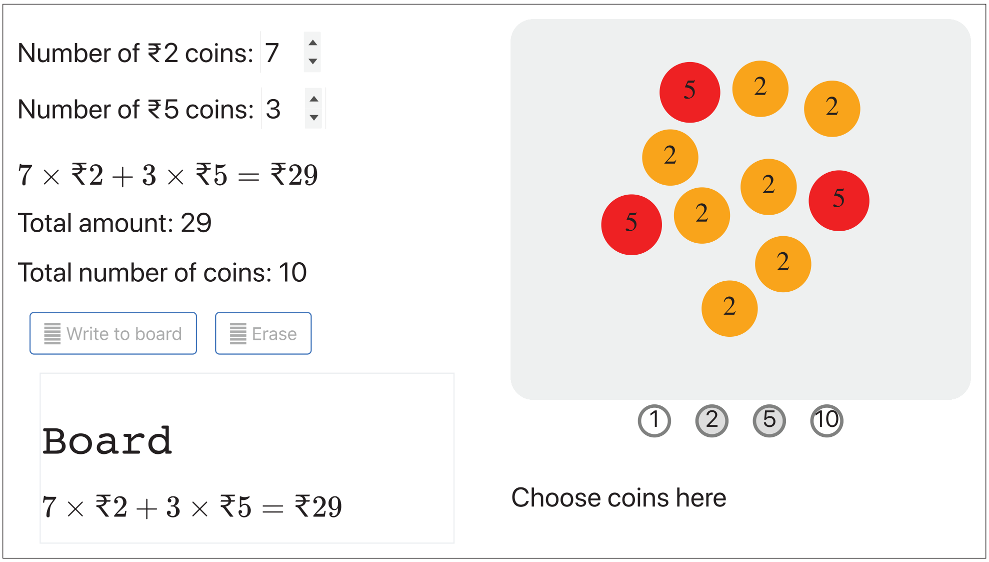

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FIGURE 7.6: The interactive instance with relevant data for the puzzle in Example 2.

We have four integral denominations, namely, 1, 2, 5 and 10. We can check the equation in Figure 7.6 by substituting each of the denominations.

For $n = 1$.

$3 \times 1 + 7m = 29$, or

$7m = 29 - 3 = 26$ or

$m = 26 \div 7$; hence this is not acceptable.

For $n = 2$.

$3 \times 2 + 7m = 29$, or

$7m = 29 - 6 = 23$, or

$m = 23 \div 7$; hence this is not acceptable.

For $n = 5$.

$3 \times 5 + 7m = 29$, or

$7m = 29 - 15$, or

$7m = 14$, or $m = 2$. [Eqn 7.6]

This is an acceptable solution. We thus have 7 coins of ₹2 (and 3 coins of ₹5) which fulfil the given conditions as indicated in the solutions posted. Thus, these two examples show how a simple puzzle can be created.

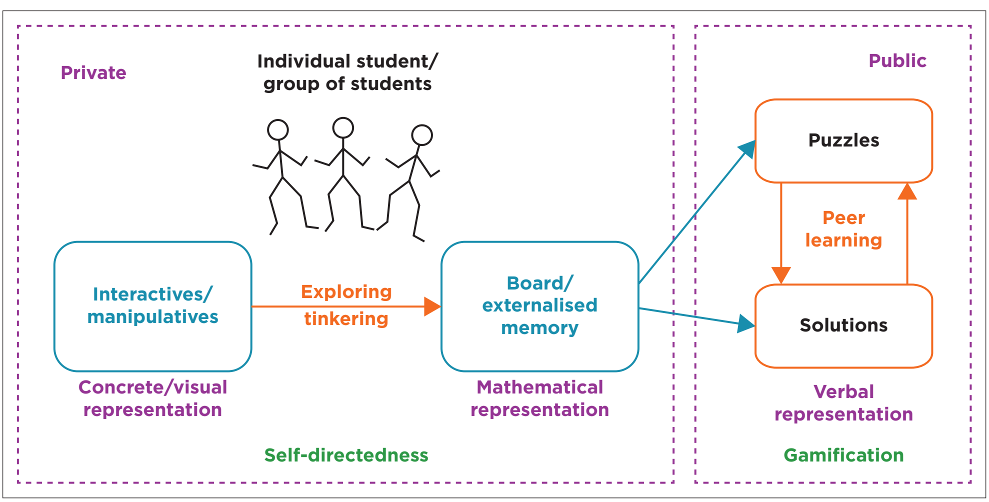
Discussion

The interactives and boards form a 'private' space for the learners that can enable SDL, while the posting of puzzles and their solutions forms the 'public' space involving gamification and peer-learning.

The movement is between the concrete situations in the interactives, and their mathematical and verbal representations. The learners can be individuals or groups of learners on a computer, and, in the latter case, it can also lead to collaborative learning.

The interactives and the online learning platform discussed here encompass several aspects of teaching and learning which are described schematically in Figure 7.7. There are two distinct spaces on the platform: private and public. The private space (as indicated in Figure 7.7) enables self-directedness, allowing the learners to explore and tinker with the manipulable mathematical objects in the interactives. These manipulable mathematical objects are in the form of concrete and visual representations, and the output is on the 'board' where it is in the form of mathematical representations. The 'board' is a private space of the learner (or group of learners). This form of externalisation of memory enables them to understand the relationship between representations and create and solve puzzles based on the information there.

The public space in the form of comments by the learners is where the puzzles and their solutions are posted. This public space forms the basis of gamification, peer-learning and peer-assessment. Here the representation



Source: Authors' own work.

FIGURE 7.7: A schematic representation of the interactives and the embedded processes of self-directedness, peer-learning and gamification.

is in verbal form; to solve them, the learners have to go back to their mathematical representation and then back to verbal or numerical representations as solutions.

The movement between the public and private spaces also enables the movement between representations. According to Dix (2008; [*emphasis in original*]), the act of writing is a form of externalisation and has a transformative effect on the writer: 'Writing forces *processing* of your ideas and reflection on them' and 'writing makes your thoughts available as the *object of study*'. In our context, the act of writing puzzles which have a coded layer of mathematical information. The task of solving the puzzle requires decoding of this mathematical information and performing mathematical operations on it to get the solution. The final step is the interpretation of the mathematical operations in the concrete context of the problem (how many coins is the required number). Thus, this part of the process involves movement between mathematical representations, which was the learning objective behind the design of these interactives:

- **Linear equations and their solutions:** The basic idea behind the interactives presented here was to aid the understanding of linear equations and their solutions by using multiple representations. We used three common and everyday contexts which are used in introducing linear equations, which are amenable to forming puzzles. These puzzles can be rich sources of discussion in the classroom. The interactives and their extension on the platform via gamification in the form of posting puzzles can further improve the learning process via peer-assessments and peer-learning.
- **Self-directedness:** The interactives provide a safe space for the learners to tinker with the objects of mathematics learning. The tinkering aspect of these interactives is essential, linking SDL to microworlds based on constructionist pedagogy (Dhakulkar & Olivier 2021). These interactives allow the learners to explore the space of different representations and enable access to the mathematical data generated from them. The interactives allow the learners to operate at their own pace and in their own (private) digital space with strong elements of self-directedness. Furthermore, there is a potential for CSCL when a group of students use the interactives.
- **Externalisation of memory:** The presence of 'boards' in the interactives was a design choice that was made explicitly to aid the externalisation of memory. The data on these boards can be effectively used to create and solve puzzles. As the interactives combine different representations, such as visual, verbal, numerical and algebraic, they can also help in movement between representations. The 'boards' provide the information in an accessible format, thus providing 'cognitive offloading' so that the learners can focus on creating and solving the puzzles. According to Risko and Gilbert (2016, p. 685), 'cognitive offloading

represents one of the quintessential examples of how we use our body and objects in the external world to help us think'.

- **Moving between mathematical representations:** The movement between representations and operating on them is a significant problem in mathematics education that the interactives will address. The movement between verbal and algebraic is especially challenging, and the design of the interactives can potentially address the challenge by providing the learners with external scaffolding in the form of visual, verbal, numerical and algebraic representations.
- **Gamification:** The gamification of mathematics learning is possible via the platform. The gamification happens in the shared (public) digital space and allows the learners to interact with each other (Figure 7.7). The idea of posting word puzzles of their own creation for others to solve can be a powerful incentive for the learners and also to develop SDL skills. The very act of producing a puzzle, which is posted on the public platform for their peers to solve, can be great motivation for the students. Also, the resulting challenge to solve a puzzle posted by a peer can be seen as a great group or personal achievement. 'Who will solve the puzzle correctly first?' can be seen as a motivating factor for the learners, which is a human trait. For example, amongst scientists, the motivation to be the first one to invent or discover something is significant. Similarly, 'Is my puzzle the toughest?' motivates learners to produce puzzles in very creative ways. Creating word puzzles can be quite a creative endeavour, as several parameters (e.g. the number of coins and the factorisation number) can be provided to form different types of word puzzles from the same data. Thus, the gamification of learning can add to the richness of the interactives and learning made possible by them.
- **Self- and peer-assessment:** The gamification via the platform enables self- and peer-assessments. One aspect of self-assessment comes in when the learner posts the puzzles. To be able to create and post a puzzle, the learner has to solve and know the correct solution. Apart from these, there are self-assessment exercises on the platform. The learners can solve puzzles posted by other learners and provide their solutions, which can be checked by the original posters and other peers and mentors (teachers). Thus, the puzzles and their solutions can be enablers of peer-assessment and peer-learning. This is a powerful feature of the platform, enabling learners to interact in a shared digital space.
- **Open educational resources:** The student platform used in the project is released under a free and open-source software (FOSS) license, and the Unit on Linear Equations is released as an OER with a CC BY license applied. These licensing terms allow both the platform and the interactives to be contextualised to other teaching–learning contexts.

For example, one can translate it into another language or change the currency in the coins puzzle. This set of resources adds to the growing repertoire of OERs.

- **Limitations:** This work discusses the design aspects of the interactives, which attempt to address some of the issues reported here, is conceptual in nature and is limited in its scope for discussions. Further empirical studies involving how the interactives were used in classrooms by students and teachers would indicate if the design was successful in its learning objectives. These studies can have multiple foci, such as mathematics education, gamification, self-directedness, collaborative learning, self and peer-assessments, and technology in education. They can enhance our understanding of how interactives which provide externalised memory can enhance learning. Finally, the cognitive aspects of solving linear equations, their mental representation and schemas, and how they are affected by such interactives, gamification and platform can be studied.

Conclusion

This research clearly shows that the design of online learning environments and their features should be carefully selected for their optimum impact. We discussed how the presence of external representations that are interactive in nature could enable SDL in an online learning environment. The features of the online learning environment can, in addition, facilitate gamification of learning, self-assessments and peer-assessments. We hope that such teaching–learning environments with multiple objectives which scaffold learning in multiple ways can be accomplished.

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Chapter 8

LEGO®-ing in the development of teacher identity

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Abstract

In realising the need to align teacher-training with the development of self-directed and critical 21st-century skills, the North-West University (NWU), South Africa, is breaking ground with the inclusion of LEGO® Foundation's Six BRICKS activities in its professional orientation programmes as part of the teaching practice curriculum and research activities. In this phenomenological study, a purposive sample of 66 first-year student teachers were exposed to a variety of engaging LEGO® Six BRICKS activities where they explored their ideas of teachers and the teaching profession, as well as prominent role-players in their journey of becoming teachers. Instead of direct efforts to instruct student newcomers to the faculty about

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professional identity and the development thereof, six LEGO® bricks are used to engage students in activities to foster conceptual understanding of the skills and attributes required by successful teachers and to prioritise each skill and attribute based on their understanding of the importance of each. A thematic analysis of photographs and narratives of these activities indicates the effect and value of hands-on LEGO® Six BRICKS activities as a play-based pedagogy in promoting self-directed learning (SDL) as first-year students shape their understanding of the skills and attributes required by the teaching profession. This chapter's unique contribution lies in exploring LEGO® Six BRICKS as a problem-based approach to developing teacher identity through the engagement of pre-service teachers in activities aimed at promoting communication and problem-solving as well as reflection and self-regulation as skills and attributes of pivotal importance for the teaching profession.

Introduction

This chapter deals with first-year student teachers' perceptions of the skills and attributes required by the profession, their aspirations as future teachers and their identification of prominent role-players in their journey of becoming teachers. It demonstrates how first-year education students can be guided in the process of identifying and reflecting on their perceptions through problem-based learning (PBL) (see ch. 1) and pedagogies of play (PoPs) (see ch. 2) as active approaches toward SDL.

After stating the problem that sparked this research, a theoretical overview will be given regarding perceptions of teachers and the teaching profession. This will be followed by a critical discussion of the theories of SDL, PBL and play-based pedagogies that underpin the activity that first-year students were requested to perform as part of the professional orientation programme that constitutes their work-integrated learning (WIL) experience in the first semester of their teacher-training. The chapter then shares information about the professional orientation programme before focusing on the study's research design. Furthermore, we share empirical data and the analyses thereof and make recommendations about the professional orientation of first-year education students before concluding the chapter.

Problem statement

This chapter focuses on two challenges experienced in the Faculty of Education at a higher education institution (HEI) in South Africa. Firstly, research conducted at this HEI (NWU) reveals that first-year Bachelor's in Education (BEd) often have a somewhat naïve view of teaching, linked to perceptions that teaching does not require high-level knowledge and skills (Petersen & De Beer 2019, p. 295). Lortie (1975) describes this phenomenon as the 'apprenticeship of observation' (AoO) and adds that it is largely responsible for many of the preconceptions that student teachers hold about the profession. These preconceptions severely affect how students approach their teacher-training and form pre-professional identity (Dayan, Khan & Ahmad 2022, p. 154; Jackson 2016a, p. 850; Rinke, Mawhinney & Park 2013, p. 93).

Secondly, studies by De Beer and Gravett (2016) and Dlamini et al. (2020, p.3) show that most first-year students who enrol for teacher-training at tertiary institutions seem unprepared to take responsibility for their own learning because they emerge from an examination-driven system. As a result of the pedagogy of 'talk-and-chalk' that they have become familiar with as school learners, they lack SDL skills, expecting their lecturers to disseminate knowledge for them and guide them in every step of the learning process (Annandale & Reyneke 2020, p. 53).

These challenges will be discussed in more detail in the sections titled 'The apprenticeship of observation' and 'Self-directed learning'.

■ The apprenticeship of observation

Globally, teacher-training institutions are confronted with the common perception that teaching is a profession that requires little formal study because it encompasses nothing more than what school learners have experienced as observers and evaluators of professionals in action over at least twelve years (Darling-Hammond & Bransford 2006; Lortie 1975). Darling-Hammond (2006) explains the notion of observers and evaluators of teaching by using the analogy of musical performance: A member of the audience may look at the conductor who waves his arms around and think there is not much to conducting a symphonic orchestra. Little does the spectator know about what happened behind the scenes to ensure the success of the performance. In the same way, school learners may think that teaching is easy as most first-year students who enrol for teacher-training at tertiary institutions seem unprepared to take responsibility for their own learning because they emerge from an examination-driven system (Lortie 1975).

According to Lortie (1975), school learners typically lack the analytical ability to critique their teachers' conduct and actions objectively, so they often favour a teacher based on personality rather than pedagogical principles. Apart from the reality that students are often drawn to teaching because of the subjective opinion of any of their favourite teachers, their decision to study teaching may also be linked to parents as teachers, family, babysitting, tutoring experiences or television programmes (Botha 2021, p. 13; Greenwalt 2014, p. 307; Manuel & Hughes 2006, p. 22). Researchers such as Darling-Hammond (2006), Jackson (2016b, p. 934) and Botha and Reyneke (2020, p. 245) highlight the importance for teacher-training institutions to challenge students' uncritical acceptance of notions about teachers and teaching as it influences their pre-professional identity formation. Linking to the argument made by Greenwalt (2014, p. 309), it is highly unlikely that student teachers will model their own behaviour on one notion of teaching practice because of their exposure to various teachers over twelve years of schooling. Smagorinsky and Barnes (2014, p. 48) advocate for pre-service teachers to be guided in focusing on both the negative and the positive impact of their previous teachers in conceptualising a vision for their own pedagogical style. Smagorinsky and Barnes (2014, p. 48) found that student teachers who reflected on their lived experiences as school learners could not only identify different traditional and progressive teaching models but could also reflect on and critique the practice of their former teachers as they started projecting visions of their own future practice underpinned by constructivist principles.

Instead of aggressively deconstructing students' perceptions that constitute their AoO, designers of the professional orientation programme opted for a structured programme that would take students on a journey of SDL.

■ Self-directed learning

Annandale and Reyneke (2020, p. 52) highlight the challenges faced by first-year university students in South Africa in bridging the gap between secondary and higher education (HE). Cognitively, the major challenge is moving from being spoon-fed to pass tests and high-stakes examinations (Brenner 2016; De Beer & Gravett 2016) to active, critical engagement with academic content (Nasri 2017, p. 7). Rantsi (2016) remarks that South African learners find the progression from secondary school level to tertiary education challenging and postulates that the gap may be attributed to the weak public schooling system. Therefore, it is of crucial importance that students who enrol for studies at the tertiary level, especially first-year students, are guided to cope with the demands of HE (Annandale & Reyneke 2020, p. 52). The focus should be on developing students' SDL skills, not only to attain academic success but also to prepare them. According to Knowles (1975), SDL can be seen as a process that an individual embarks on by determining their own learning needs. Once needs have been identified, clear learning goals are set, resources are searched for and appropriate learning strategies are selected and implemented. The final step is to evaluate one's own learning. The SDL process can be embarked on independently or with the help of others (see ch. 1). The idea is for student teachers to become increasingly self-directed as they mature, which is an essential proficiency skill for in-service teachers to thrive in the ever-changing field of education. In fact, the three SDL goals described by Merriam, Caffarella and Baumgartner (2007) are pertinent to teacher-training and pre-professional identity formation: To promote academic self-determination, foster transformational learning, and enhance emancipatory learning and social action, which form an integral part of SDL.

In terms of Goal 1, Rogers (1983) highlights the need for a sense of discovery coming from within the student in starting the move from a self-reliant personality towards one of self-direction and autonomy. The next goal, transformational learning, may be attained through a process of critical reflection which is an intrinsic and critical component of SDL (Brookfield 1986). Critical reflection and transformational learning support the final goal of promoting emancipatory learning and social action (Merriam et al. 2007). In the context of this study, the developers of the professional orientation programme (as teacher educators) focused on facilitating a process through which first-year education students would be guided in reflecting on their self-reliant perceptions of teaching and the teaching profession and note attributes and skills sought after by the profession as expressed in documents such as the *National Qualifications Framework Act Policy on Minimum Requirements for Teacher Qualifications* (MRTEQ) (Republic of South Africa [RSA] 2015, p. 11). The eventual goal remains to foster critical teacher skills such as self-directedness to emancipate themselves and become agents of positive change in education.

Instead of placing first-year students in schools a mere three months after finishing their high school (Grades 8–12) studies and running the risk of confirming any existing AoO that might have a negative influence on training, academics responsible for WIL opted for a structured professional orientation programme that would take students on a journey of SDL. As pointed out by Knowles (1975), the first step of the SDL journey would be for students to identify gaps in their own understanding, in this case, their understanding of the attributes and skills required by the profession. The hypothesis, confirmed by various scholars in the field of teacher education quoted, was that once students' awareness was raised of their naïve or one-dimensional perceptions of teacher skills and attributes in disrupting their AoO, they would be in a better position to formulate their own learning goals and become more receptive to training. As newcomers to teacher education, students needed to be guided to critically reflect on their beliefs regarding teacher skills and attributes as well as important role-players in preparation for the profession (Botha & Reyneke 2020, p. 232; Darling-Hammond 2006, p. 4; Darling-Hammond & Bransford 2006; Jackson 2016b,

p. 934; Lortie 1975). A metacognitive task, based on the challenge of AoO, had to be designed so that student teachers would want to engage with it and be comfortable sharing their personal perceptions and thoughts as they learn to take responsibility for the development of their own pre-professional identity. According to Freire (1970), self-direction and self-determination can only be achieved when we favour problem-based education.

Problem-based learning

Hmelo-Silver (2004, p. 240) explains that PBL caters to formulating effective knowledge between the lecturer and the students. Instead of 'chalk and talk' that comes down to nothing more than the lecturer transmitting knowledge to the student, the pedagogy of PBL stimulates critical thinking, problem-solving abilities, and dialogue between the two parties and among students. The latter engagements should be ensured by the design of PBL tasks to give students a sense of control, independence and responsibility so that SDL and self-regulated learning (SRL) skills may be developed. From the instructor's side, there should be quality scaffolding of students' knowledge and learning (Khoiriyah & Hussamah 2018, p. 156). Scaffolding, which should act as an enabler (Benson 1997, p. 127), often involves posing multiple problem-related questions that direct students to respond using selected learning resources (Atta & Alghamdi 2018, p. 624). In this study, problem-related activities guided participants through a process of critical engagement, collaboration and reflection with the aim of disrupting their AoO in preparation for teacher-training.

While PBL is centred around challenging students to solve a problem that is aligned with learning outcomes, the PoP could be used to encourage creativity engagingly.

Play-based learning

In contrast to popular belief, Leather, Harmper and Obee (2021, p. 209) state that it is not only learners who explore through play. Siviy (2016, p. 13) agrees that playfulness is a state of mind that many adults want to be in because it minimises feelings of pressure, tension and conflict when difficult situations are to be explored (Hendricks 2015; Šimůnková 2018, p. 57). Moreover, adults benefit from opportunities to think creatively, connect ideas, and apply knowledge and skills without being concerned about a wrong answer or finding the right answer, liberated by the notion that everyone can succeed in play (LEGO® Foundation 2021a). Solis et al. (2019, p. 8) and Nolan and Paatsch (2017, p. 52) add that playful learning develops intellectual skills and social, emotional and physical abilities. Other benefits include divergent thinking, emotional regulation, imagination, humour, motivation, positive emotions and problem-solving skills (Gordon 2014, p. 249; Guitard, Ferland & Dutil 2005, p. 15). Siviy (2016, p. 13) believes that PoP should already be introduced at the school level as engaging adolescents in play may lead to adults who can navigate a changing social, emotional and cognitive landscape.

Play-based activities at the tertiary level encourage students to explore systematically, experiment and continually iterate while learning becomes experimental, motivating, memorable and meaningful. In a world mostly driven by the exponential growth in technology, it has become increasingly important to promote the holistic development of students, more so in the case of pre-service teachers who need to be equipped with 21st-century skills pertinent to the profession, such as communication, collaboration, problem-solving, and creativity (Jacquelyn et al. 2017, p. 47; Rotherham & Willingham 2009, p. 20; Teo 2019, p. 176). Holistic development, which includes the development of soft skills while engaging in play-based activities to solve problems aligned with learning outcomes, is believed to contribute to feelings of success and happiness (Keung & Cheung 2019, p. 636). On the other hand, recent studies in education report on learners disengaging from and not thriving in pure digital settings (Bergdahl & Bond 2022, p. 2653; Gillett-Swan 2017, p. 28).

This study used a problem-based approach in challenging first-year education students to identify their ideas about teaching, evaluate these ideas and reflect on the profession as a first step in becoming a teacher, that is, taking responsibility for shaping their identities as future teachers. We used guided play, that is, play with some involvement from the lecturers (Holt et al. 2015), in this case, guiding questions.

We favoured the idea of student involvement with physical hands-on activities instead of digital activities. LEGO® offered the ideal solution as the LEGO® Six BRICKS initiative allows for manipulating concrete tools to explore and make meaning of challenging concepts.

■ LEGO® as an alternative spatial tool to explore identity

LEGO® is known as interlocking plastic block-shaped toys that children use to construct anything they can imagine. The word LEGO® is an abbreviation of the two Danish words '*leg godt*' meaning 'play well' in English (LEGO® Foundation 2021a). According to the LEGO® Foundation (2021a), it has been part of the schooling system over the past three decades and has been used to promote learning in language and literacy, science, computing, mathematics and technology. While different sets have specifically been created as educational sets (LEGO® Foundation 2021a, 2021b), LEGO® Six BRICKS is a concept designed by Brent Hutcheson, the director of Care for Education, a non-profit organisation in South Africa that aims to train teachers in all subjects and phases of education to include LEGO® in their pedagogy, and to excite and motivate students to learn through playing with six Duplo® blocks in different colours (LEGO® Foundation 2020).

Based on the need for lifelong learning in a rapidly changing world, and the impact of technology where foundational skills are crucial, it is increasingly important to assist students in developing 21st-century skills such as collaboration and communication, creative thinking and problem-solving.

Empirical research

Research paradigm

The research embarked on in this study is underpinned by constructivism. Constructivism focuses on the role of people in constructing knowledge, stressing the notion that experience is perceived subjectively and not objectively (Crotty 1998). In the context of this study, based on their unique experiences and perceptions, students construct their own understanding of teacher skills and attributes and of important role-players in their journeys of becoming teachers.

Research design

A qualitative research design was selected because it is exploratory and allowed the researchers to develop an understanding of the reasons and opinions of individual participants based on their personal experiences (Hennink, Hutter & Bailey 2020). With this study, the researchers wanted to gain access to first-year students' perceptions of crucial teacher skills and attributes and important role-players in their individual journeys of becoming teachers to determine the role that AoO might play in pre-professional identity formation. By adopting this research design, researchers acknowledged that there is no absolute truth and that new information and knowledge emanating from the study would be situational and derived from the personal experiences of each participant (Roller & Lavrakas 2005). This notion is highly applicable to the study as a wider and deeper understanding of students' perceptions was sought to allow for a deeper understanding of the AoO.

Methodology

Within the qualitative research design, the phenomenological method was applied because researchers wished to gain a deeper understanding of the phenomenon that literature refers to as AoO and the possible effect thereof on pre-professional identity formation. As highlighted in the literature, student teachers' AoO is a challenge that should effectively be dealt with as a first step in guiding prospective teachers in developing their pre-professional identity (Darling-Hammond 2006, p. 13; Jackson 2016b, p. 935; Lortie 1975; Smagorinsky & Barnes 2014, p. 48). Following a problem-based approach, the play-based activities in this study were set up to deal with this challenge. Based on their unique experiences as school learners, students' perceptions were activated by the LEGO® Six BRICKS activities, where they could manoeuvre the blocks as they wished before writing reflective narratives. Aligned with the phenomenological method, the study considered participants' perceptions during the activity. The narratives generated the data for the study. The study also considers how participants experienced specific events or activities. Thus, a database with themes was formed to validate the findings. Ethical clearance was obtained from the institution involved.

☐ Sampling and data analysis

A purposive sample was drawn from the narratives submitted by all first-year students enrolled for a BEd at the NWU. Purposeful sampling is a sampling method used in qualitative research design for the researcher to identify and select information-rich cases that relate to the real-life situation being explored (Creswell & Cresswell 2017; Palinkas et al. 2015, p. 3). In this study, the researchers randomly selected 66 narratives from the larger first-year group. These narratives were constructed based on students' engagement with the LEGO® Six BRICKS activity, during which they explored their ideas of teachers and the teaching profession, as well as prominent role-players in their journey of becoming teachers. This study forms part of a larger research project for which full ethical clearance, gatekeeper permission and student informed consent were obtained. These photographs and narratives were then imported into ATLAS.ti™ (ATLAS.ti Scientific Software Development GmbH) where the researchers read and reread the students' narratives to, through inductive analysis, identify themes. These themes were coded and will be discussed in the 'Student activities' section.

☐ Student activities

In this study, each first-year student teacher was given a set of LEGO® Six BRICKS and asked to perform the following task: The pre-service students were asked to construct a tower of their LEGO® Six BRICKS (Figure 8.1) with the skills and attributes they believed were important for teachers (see Box 8.1).

After students constructed their LEGO® towers, they had to take a photograph of their tower and write a narrative to explain their perceptions

Source: Photograph taken by Elma Marais, date unknown, location unknown, published with permission from Elma Marais.
FIGURE 8.1: LEGO® Six BRICKS.

BOX 8.1: Task requirements.

Task requirements

1. Take the six bricks you have received and place the six individual bricks in a straight line before you.
2. Identify six crucial skills or attributes that you believe teachers should possess and assign each skill or attribute to a specific coloured brick.
3. Now build a tower with the six bricks, starting at the bottom with the least important skill or attribute and putting the most important skill or attribute at the top. Take a picture of your tower so you can submit it with the narrative requested in Step 4 below.
4. Make written notes on what each skill or attribute means to you as a future teacher. Justify your ideas. Then write a narrative in which you reflect on the skills and attributes that are important in your journey of becoming a teacher.
5. There are certain basic competencies that beginner teachers need to have once they finish their pre-service training. These have been listed in the MRTEQ.
6. Now reconsider your tower. How many of these competencies did you address in your first becoming attempt? Would you now like to make some changes? Would you like to change the skills or attributes that you have allocated to certain bricks? Would you like to change the order of the bricks in your tower? Remember to also make these changes to your notes!
7. Once you have finalised your tower and your notes, create a table with the following column headings: Colour, skill or attribute, and justification.
8. Take apart your tower again, and now consider each brick as a role-player part of your journey to becoming a teacher.
9. Build a cube where you indicate the importance of and interaction between these role-players. Take a photograph of your cube and add it to your MS Word document.
10. Write a paragraph where you identify each role-player, justify the placement for that specific colour in your cube and indicate the value of this role-player in your journey of becoming a teacher.

Source: Authors' own work.
Key: MRTEQ, minimum requirements for teacher qualifications; MS, Microsoft.

of these skills and attributes in the context of becoming a teacher. Then they had to take their towers apart and consider each brick as a role-player in their journey to become a teacher. Next, they were requested to build a cube, indicating the importance of interaction between these role-players. Students had to take a photograph of their cube and add it to their Word document before writing a paragraph where they had to identify each role-player, justify the placement for that specific colour in their cube and indicate the value of this role-player in their journey of becoming a teacher.

Discussion of findings

Perceptions of attributes and skills teachers need

Based on their experiences, first-year student teachers named various attributes and skills that they believed were important for the profession. A thematic analysis of the qualitative data strongly portrayed the following four themes: *Communication*, *patience*, *leadership* and *adaptability* (Botha & Reyneke 2020). Quotations that follow below are verbatim and unedited.

Several participants commented on communication with learners and communication with colleagues and parents. Student teacher 01 believes that:

> '[...] teachers are known for the fun spirit and extrovert qualities, hence being a good communicator is a very important aspect for being a successful teacher.' (Line 12, gender undisclosed, March 2021)

Participants evidently confused communication skills with pedagogical skills as is clear from the following remark from Student teacher 02:

> 'Teachers need to have communication skills and the ability to stand in front of other people.' (Line 04, gender undisclosed, March 2021)

Another remarked that the skill to communicate would help them get their message across to students effectively and would assist in explaining some concepts quite easily. Participant responses indicate their ignorance about pedagogy at the beginning of their studies. This statement validates Lortie's (1975) AoO that highlights this naïve view that many students have of pedagogical matters. The one-dimensional understanding of communication in a teaching environment is also important to note. The notion that communication skills are synonymous with pedagogical skills should be challenged at the onset of teacher-training, and these different skill sets should be developed during their studies and practised during periods of teaching practicum.

Another prominent theme was 'patience'. A participant believed that they had to be patient as it would not help to get angry with the learners for not understanding the subject or being rude and disruptive in the classroom (Student teacher 33, line 31, gender undisclosed, March 2021). The attribute of patience clearly correlates with some sense of pedagogy. Student teacher 18 agreed in stating that:

> 'Patience is the key in life. You have to be patient at all times with all kinds of learners. It's important, because there are learners who are slower than others, which means you have to deal with them.' (Line 09, gender undisclosed, March 2021)

The attribute of 'leadership' also emerged from the data analysis. It was interesting to note that participants' explanation of leadership correlates with the level of respect that they expect learners to show them when they enter schools. According to one participant, leadership skills in the classroom will lead to learners being engaged and interested in what is presented (Student 61, line 03, gender undisclosed, March 2021). They see leadership skills as important because they believe they will help them manage the classroom and ensure learning goals are achieved. Some student teachers seem to think that leadership will automatically constitute a manageable classroom. Student teacher 14 stated:

> 'Leadership skills can also be helpful in the classroom teachers will need to lead their classroom, keeping their learners engaged and interested. This skill is important because it can help you with managing the classroom and highlighting the importance of upcoming due dates or project goals.' (Line 18, gender undisclosed, March 2021)

Student teacher 30 agreed that leadership would facilitate classroom management but indicated that it may lead to additional responsibilities:

> 'Teachers require leadership abilities both in and out of the classroom. Modelling behaviour for pupils can help them build a passion for study and a sense of general responsibility. When dealing with teachers and school administrators, leadership is also crucial. Teachers with good leadership qualities may accept additional responsibilities such as coaching a sports team or leading a particular interest club such as chess or drama. Teachers who have improved their leadership skills are more likely to rise to senior roles such as principal or superintendent and they will be able to manage their classroom.' (Line 24, gender undisclosed, March 2021)

During the process of pre-professional identity formation, it would be important to focus on the characteristics of a good leader and to discuss how respectful relationships ought to be established in a classroom (Botha & Reyneke 2020).

'Adaptability' emerged as a fourth strong theme in data attribute analysis. Participants mentioned the skill to adapt to different contexts and learners, the ability to be flexible in a changing environment, and the ability to support learners to cope with a changing environment. This concept might have featured strongly because the participants had been challenged to adapt to constant changes, especially in education, over the past two years of the coronavirus disease 2019 (COVID-19) pandemic. Other attributes that were mentioned and linked to the theme of adaptability were perseverance and resilience.

Student teacher 07 stated:

> 'Adaptability is an orange brick since it refers to me being able to adapt to new environmental changes and the use of technology. I have to be able to change if it is needed.' (Line 08, gender undisclosed, March 2021)

Student 58 linked the attribute of adaptability to their journey of becoming a teacher:

> 'Lastly, is my father, Mr Z (Red), who has forever been showing skills of adaptability in life especially ever since covid started and I know that he amongst other people he can instil the skill of adaptability in me hence pushing me onwards on my journey to become a teacher.' (Line 25, gender undisclosed, March 2021)

It is positive to note that student teachers seem to be aware of the importance of these attributes – adaptability and flexibility will serve them well as they start their teaching careers in the ever-changing 21st century. Resilience would be needed to successfully face various challenges linked to the profession and persevere when the going gets tough. Several students indicated that they see resilience as an important attribute of a teacher.

Student teacher 10 stated:

> 'I will need resilience as it allows one to grow and learn in all situations, enables one to approach new situations and people with confidence and a positive mindset which will promote success.' (Line 06, gender undisclosed, March 2021)

Student teacher 60 stated:

> '*Resilience* – when teacher is resilience they are able to bounce when a teaching method is not working and they try another one.' (Line 12, gender undisclosed, March 2021)

Student teacher 42 stated:

> 'Resilience: when either one my friends faces adversity, they do not let it ruin the day, they keep moving forward. It is what I have come to learn to keep believing in myself even if the day is too tough to handle. I will need to do the same if I am a teacher.' (Line 34, gender undisclosed, March 2021)

Student teacher 42's comments on resilience correlate with their understanding of perseverance. Student teacher 10 explained it:

> 'As a teacher you need to instil confidence, build a student's ability to persevere so it is easy for students to deal with failure as they shouldn't be praised for success only but also effort.' (Line 02, gender undisclosed, March 2021)

Student teacher 01 expressed their belief that there will be difficult moments in teaching, but you have to keep going:

> 'I have to keep going even when you feel there's no hope, there is a light at the end of every tunnel.' (Line 15, gender undisclosed, March 2021)

Participants mentioned other skills and attributes: Learner's needs, class discipline, collaboration, confidence, conflict resolution, consistency, control, critical thinking, dedication, empathy, fairness, work ethics, integrity, caring and group work. The mentioning of various skills and attributes can be linked to first-year student teachers' different backgrounds and experiences. Each student teacher built their tower from their unique perspective of what makes a good teacher. Interestingly enough, first-year student teachers generally focused much more on soft skills than on the cognitive aspects or academic requirements of teaching. This links to the concern that Lortie (1975) and Darling-Hammond and Bransford (2006) had about the influence of the AoO, especially the latter's use of the analogy of the conductor of an orchestra referred to above in making the point that it all looks so simple and easy. While one does not ignore the important role soft skills play in effective teaching, it is apparent from the data analysis that participants seem ignorant about the profession's cognitive and pedagogical demands. None of the participants mentioned a high level of content knowledge or the importance of pedagogical knowledge and skills. Neither did they mention any attributes related to handling administrative duties such as creating your own structure, being organised in planning and in record keeping. The picture of a teacher that emerged from the data was one who cared, not necessarily one who is a subject expert or notably skillful in transferring subject knowledge.

Beijaard, Verloop and Vermunt (2000) identify three components of teacher identity: Subject matter expert, pedagogical expert and didactic expert. The development of this identity is influenced by teaching content, experience and biography. In that regard, the self-directed LEGO® Six BRICKS activity was used effectively to challenge pre-service teachers to critically consider their biography and expose them to the parts of professional development they might not yet be aware of. Their responses indicate areas for development.

☐ Perceptions of important role-players in their journeys of becoming teachers

Students mostly commented on the importance of relationships, the availability of resources, knowledge and attributes required by the profession. The following section will discuss these perceptions that will influence their pre-professional identity formation.

Relationships

Participants commented on the importance of relationships inside and outside the educational context and referred to people and relationships that influenced their decision to study education and relationships that they think may influence their journey to become teachers.

Attributes and skills inside the educational context

Relationships with learners

Based on some participants' experiences and perspectives, they indicated a heartfelt wish to help learners succeed in their lives, expressed in statements such as:

> '[…] every child needs the right to education, no matter what their circumstances are, and if I can help in achieving this, I want to.' (Student teacher 55, line 04, gender undisclosed, March 2021)

In the same vein, participants remarked on the influence of caring teachers on them and how these relationships contributed to their choice to become teachers. It is important to note that this notion of caring seems to be a defining feature in the pre-professional identity of the participants.

The sense of teaching as a calling was furthermore supported by student teachers placing blocks in their tower that addressed the concept 'to teach is to care'. One participant indicated that they associated the orange LEGO® Duplo® block with caring as it makes them think of the sun and that their role as a teacher will be to care for children (Student teacher 58, line 18, gender undisclosed, March 2021). Student teacher 26 (line 14, gender undisclosed, March 2021) stated that:

> '[…] education is the most rewarding job on earth if you are a teacher that loves and care for your learnings. You have to make a difference in their lives.'

The idea of loving and caring was also expressed in responses such as:

> 'Love is the most important thing to have as a teacher because love brings patience and understanding. It also creates a strong bond between you and your learners. As a teacher, you need to go the extra mile to demonstrate your love and show care to learners, it makes them be motivated and more likely to learn and engage with you.' (Student teacher 51, line 26, gender undisclosed, March 2021)

Once again, the need for soft skills featured strongly, especially in terms of an inclusive and accommodating approach to teaching. However, data on relationships with teachers portrayed some awareness of teachers' content knowledge and pedagogical skills.

Relationships with former teachers

It was evident from the data analysis that former teachers played a significant role in what first-year student teachers believed about teachers and the teaching profession and in their decisions to become teachers. Participants associated their favourite teachers with specific colours:

> 'My yellow brick is my former accounting teacher who persuaded me into choosing this career, with the experience he has, an aspiring teacher like myself can learn a lot from him in terms of knowledge and teaching skills in this field.' (Student teacher 04, line 15, gender undisclosed, March 2021)

> 'My former Grade 3 teacher is yellow and played a huge role in the journey of my life as I decide to do teaching. She made it look easier, enjoyable and much easier than it may be. She taught me the best and that you should never give up and grab every opportunity that comes your way.' (Student teacher 45, line 34 gender undisclosed, March 2021)

> 'Green and light blue, my mentor and teacher, Mrs M. She is a blessing to me and showed me how things are and made me choose the best career in my life. I learnt a lot from her because she was my early childhood development teacher that really made me to be the best that I am.' (Student teacher 33, row 23, gender undisclosed, March 2021)

Student teacher 58 (lines 20–29, gender undisclosed, March 2021) chose to assign four of the colours in the set of six blocks to different teachers who greatly influenced their life. Figure 8.2 provides a visual presentation of their cube:

> 'The first role player of my life is my mathematics literacy teacher in high school, Mr S (Light Blue) he is one part of why I am doing teaching right now and it was also his enthusiasm when it came to teaching and other mural activities that have now inspired this skill for me. The other role player in my life has to be my

Source: Photograph of the activity by Student teacher 58, taken by Elma Marais, date unknown, location unknown, published with permission from Elma Marais.

FIGURE 8.2: Example of a brick of role-players (Student teacher 58).

> former life sciences teacher Ms. R (Blue), she had taught us that an organized book leads to an organized life and an organized life leads to great academic success; hence she is an important role player for me. My next role player is my former principal in high school Mr E (Orange), he was also my business teacher and the reason why he's my role player is that he always showed a sense of leadership where ever he went in the school and that showed me how much of a responsible man he is when it came to leading by example to his colleagues and his students and hence I believe that he can instil that same sense of leadership within me. Above all my former teachers in high school, my geography teacher Ms. S (Yellow) who, had the biggest influence on my time management skills, hence she is also a role player in my life. She would always have everything she did have a certain time of completion and it would be just that so I believe that she can have the biggest influence to my time management skills.' (Student teacher 58, lines 20–29, gender undisclosed, March 2021)

Other student teachers' comments link to the argument made by Greenwalt (2014, p. 309) that learners will be exposed to various teachers over twelve years of schooling and that it will be highly unlikely that student teachers will model their own behaviour on one notion of teaching practice. Examples include:

> 'The green block is my teachers at school. I learned a lot of valuable lessons from them, both positive and negative that I could use in my career as a teacher. I learned what will work for me as a teacher and what not out of my positive and negative experiences in school.' (Student teacher 61, line 25, gender undisclosed, March 2021)

> 'I associate red with my teacher who taught me how to manage a class. You need to be strict; it is not as easy as it seems but I will do the same.' (Student teacher 02, line 37, gender undisclosed, March 2021)

This comment confirms the importance of guided reflection (highlighted by Smagorinsky & Barnes 2014, p. 48) for student teachers who must embark on constructing their own pre-professional identity. As discussed earlier, these researchers call for pre-service teachers to be guided in reflecting on both the negative and positive impacts of their former teachers so that they are scaffolded in conceptualising a vision for their pedagogical style and professional identity. The play-based activities proved to be highly effective in this regard.

Participants also commented on their relationship with the institution where they enrolled for teacher-training and their relationship with the faculty.

Relationships with the university and with the faculty

Some participants mentioned the role of the university as a place where student teachers hoped to gather knowledge as well as the role of university lecturers. Although most participants did not identify the institution and its staff as role-player, some indicated that the university played a vital role in their journey to becoming teachers. These participants did not place the blocks representing the institution or staff at the base of their cubes but either in the middle or on top, which indicated that they did not see them as foundational aspects of their journeys of becoming teachers but as role-players that should be considered. Student teacher 05 explained:

> 'On the third brick, the dark blue brick is the university where I am currently studying and acquiring all the knowledge, skills and expertise required to become a pedagogical practitioner.' (Line 15, gender undisclosed, March 2021)

A statement like this illustrates the realisation that lived experiences as a learner at school alone do not prepare one for the profession. The following response focused on the qualification rather than the acquisition of knowledge and skills:

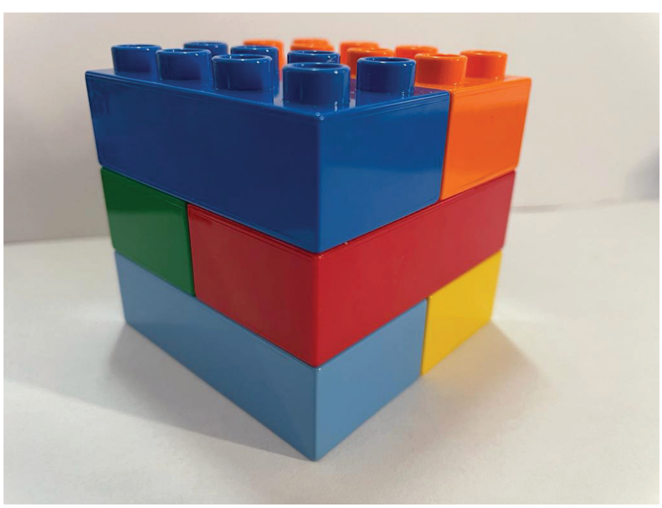
> 'Orange stands for university, it is important because it is the only way where I can obtain my degree for teaching.' (Student teacher 42, line 28, gender undisclosed, March 2021)

Another participant commented on the role to be played by the university in promoting inclusion, social cohesion, and equity:

> 'Dark blue represents university, I placed it at the top because university is the centre of learning it is where I gain substantive personal benefits, including specific skills and capabilities throughout my university life. University will help me gain dignity, it will help me respect every person, regardless of gender, sexual orientation, or gender diversity.' (Student teacher 32, line 22, gender undisclosed, March 2021)

Figure 8.3 presents a visual representation of Student teacher 32's cube.

The following section focuses on role-players outside the educational setting, as commented on by student teachers.



Source: Photograph taken by Elma Marais, date unknown, location unknown, published with permission from Elma Marais.

FIGURE 8.3: Student teacher 32's cube formed by LEGO® Duplo® bricks.

Attributes and skills outside the educational context

The analysis of the qualitative data highlighted the important role-played by the community, family, friends and religion in first-year students' decision to study teaching and in supporting them in their journey of becoming teachers.

Student teachers' sense of *community* relates to their feeling of a calling, as discussed concerning the relationship with learners. Student teacher 57 (line 18, gender undisclosed, March 2021) remarked on the need for change in the community: 'I hope that I will do better and believe that I will bring about change if I become a teacher'.

Another participant associated community with the orange brick and aimed to give back to their community with the skills they learnt at university because the community was supportive in encouraging them to become a qualified teacher (Student teacher 22, line 13, gender undisclosed, March 2021). Student teacher 44 acknowledged the influential role-played by the community when they remarked that:

> '[...] the kids from my community helped, by making me realize that teaching is what I want to do by choosing me to help them with their schoolwork.' (Line 22, gender undisclosed, March 2021)

Family played a determining role in some students' decisions to enrol for studies in education. Participants commented on their families, ranging from grandparents and parents to siblings and cousins, who supported and motivated them. Some specifically remarked on the fact that their parents or grandparents were teachers. Student teacher 24 (line 15, gender undisclosed, March 2021) stated that both their parents were teachers and did not only motivate them to become a teacher but also guided them in best practices. While the student teacher might appreciate the guidance from their parents, a crucial part of their teacher-training would be to attain a high level of knowledge and skills so that they will be able to reflect critically on their parents' practice in the formation of their own pre-professional identity.

Some participants who identified the family as an important role-player constructed their cubes with the family brick at the bottom and justified the placement by indicating family support as a foundational aspect. Participants selected different coloured bricks to represent their families and remarked on the lessons learnt from them while growing up. These lessons included being motivated, loving and caring for others, patience, the importance of good communication, overcoming challenges, taking responsibility, not overreacting, good time management, self-confidence, the importance of a wide vocabulary and word choice, enthusiasm and dedication. One student teacher mentioned their father, who taught their the importance of patience, while another remarked on a cousin who taught them to drive a car in a 'caring manner' (Student teacher 55, line 27, gender undisclosed, March 2021). These skills, which mostly fall in the category of soft skills, are typically developed in family settings and contribute to forming a pre-professional teacher identity.

Participants also mentioned *peers and friends* that form part of their support structure in their journey of becoming teachers:

> 'My best friend is light blue as he is always by my side. He is ambitious about dreams and believes in me.' (Student teacher 01, line 29, gender undisclosed, March 2021)

> 'Green symbolises friends – [t]hey provide support and resources. Comparing notes with your friends you'll see what information they believe is most important. You can discover new methods of note-taking.' (Student teacher 38, line 34, gender undisclosed, March 2021)

> 'We need our peers a lot during our journey of becoming teachers and they help us in changing ideas on which we build upon ourselves. Together we gain an understanding of different theories around teaching and without them we would struggle, hence I put them last as they are an important part of my journey of becoming a teacher.' (Student teacher 48, line 24, gender undisclosed, March 2021)

These remarks indicate first-year student teachers' realisation of the importance of group work and how they start forming communities of practice in taking responsibility for their academic progress.

Finally, student teachers' relationship with God, that is, their *religion*, was highlighted as an important role-player. Student teachers often placed religion (together with family) at the base of their LEGO® cube, indicating that religion played an important role in their decision to become teachers and in the type of teacher they wanted to become. Their religion and Bibles guided them to become the best teacher possible:

> 'My second foundation brick is dark blue, it represents commitment in my faith in God, Man lets you down, but God never breaks His promises. Therefore, I learn how to be committed to my job as a teacher in faith to the children.' (Student teacher 02, line 14, gender undisclosed, March 2021)

> 'The Bible is my guide to stay on the right path when I will be teaching. Supporting human dignity and love for your fellow man.' (Student teacher 29, line 28, gender undisclosed, March 2021)

> 'God is my foundation brick as I would not be where I am without God.' (Student teacher 07, line 19, gender undisclosed, March 2021)

It became evident that religion guided the lives of many first-year student teachers and influenced how they saw themselves and the approach they would have to their studies and the profession. Ultimately their spiritual awareness and being would influence their pre-professional identity formation.

The next major role-player that participating student teachers commented on was resources.

☐ Resources

Access to resources, both digital and non-digital, is featured as a prominent theme. This aligns with Marais (2021, p. 171), who indicates that COVID-19 illustrated that we need teachers to create their own resources. The prominence of resources as a role-player may indicate a general perception among first-year student teachers that one's success as a teacher depends on the availability of resources:

> 'Dark blue color represents resources. Without resources it will be difficult to teach, so the color shows that with the use of resources there is intelligence as teaching will be easy, so it will give me motive.' (Student teacher 13, line 24, gender undisclosed, March 2021)

This comment shows that for this student teacher, resources may equal intelligence and that resources will motivate the pre-service teachers and make teaching easier.

☐ Digital resources

Participants indicated that their ability to teach would be shaped by their ability to use digital tools and resources. These include the Internet to find information, a computer to access information and presentation hardware to use while they may be presenting lessons. Student teacher 8 (line 48, gender undisclosed, March 2021) commented that digital resources allowed them to explore varied learning experiences and familiarise themselves with different technologies as they are living in the 21st century.

The belief that technology is the cornerstone of teaching may hugely affect pre-professional identity formation. As part of their teaching practicum, student teachers should be confronted with the reality of the diverse educational landscape in South Africa – an experience that will influence pre-professional teacher identity formation. As many of them might start their careers at schools with no digital resources, it is important for them to learn how to adapt their pedagogy.

The strong reliance on digital resources may have been influenced by first-year student teachers' experiences during the past two years of the COVID-19 pandemic. During this time, many of them had to rely on access and the ability to use digital resources to learn. Those who enjoyed access to digital resources could comment on the use and value of digital resources, while those who had to cope in an environment where digital resources were not easily available relied on printed material.

☐ Non-digital resources

Some participants indicated that textbooks played an important role in their journey of becoming teachers:

> 'Textbooks are giving me the information that I need to teach.' (Student teacher 02, line 40, gender undisclosed, March 2021)

> 'I believe that academic excellence is through textbook material and resources that can help me be knowledgeable about the content I want and need.' (Student teacher 16, line 47, gender undisclosed, March 2021)

While the value of both digital and non-digital resources cannot be ignored, it is important to evaluate why first-year student teachers may see resources as an important role-player. Their perceptions may once again be based on their experiences as school learners where teaching and learning could have been textbook-bound and where assessment tasks focused on regurgitating what was written in the textbook or support material. Considering an ever-changing 21st-century society, it is important for teachers in training and for teachers in practice to be self-directed in lifelong learning to ensure that they are on par with the latest developments in their disciplines and that they contribute to knowledge generation. Apart from the focus on content knowledge, pedagogical knowledge and skills should continuously be developed and adapted as the teacher ensures relevance for learners in specific contexts. It is disconcerting, though, that knowledge of subject content did not feature as an important role-player in teacher-training.

☐ Content knowledge

Very few participants commented on teachers' need to know their disciplines. Those who mentioned content knowledge equated their former teachers' level of knowledge to good Grade 12 results: 'Light blue represents my Grade 12 results and my hard work' (Student teacher 04, line 13, gender undisclosed, March 2021).

One of the participants that acknowledged the importance of content knowledge shared little or even no understanding of the importance of pedagogical knowledge and skills or of pedagogical content knowledge:

> 'I believe knowing the subject I am going to teach makes things easier for me and the student as I will be able to glide through content and be able to explain it to learners easily, knowing what the subject is about and the content

of the subject makes teaching very easy.' (Student teacher 54, line 18, gender undisclosed, March 2021)

It ought to be highlighted that teacher-training needs to focus on developing all these knowledge domains (Shulman 1986) that make up the armour of a successful teacher. Each aspect plays an important part in student teachers' forming of pre-professional identity.

Reflection on problem-based learning and play-based learning for student engagement and the promotion of self-directed learning skills

These pedagogies can only be reflected from the researchers' perspective because it was not the purpose of the study to evaluate how effective the implementation of PBL and PoPs were from student teachers' autoethnographic perspectives. However, the data generation indicates students' active engagement with the task that guided them to unpack and reflect on their perceptions of teachers, the teaching profession and prominent role-players in their journey to become teachers. They were referred to the basic competencies that beginner teachers need once they finish their pre-service training, as stipulated in the MRTEQ, to identify gaps in their understanding. According to Knowles (1975), students' identification of gaps in their own understanding is the first step in the SDL process. What follows is that students should formulate learning goals to address the gaps that they identified. They should then be able to select resources to meet their learning goals, identify learning strategies and finally, students should evaluate whether they have met their learning goals.

In linking with the problem statement that drove this research, hands-on LEGO® activities as play-based pedagogies proved to be successful in raising first-year students' awareness of their perceptions about important role-players as well as skills and attributes needed for the profession and how their perceptions may be misaligned with actual requirements (Petersen & De Beer 2019). Furthermore, as newcomers to the university, first-year students were requested to engage actively with the activities in disseminating knowledge as they embarked on the SDL process.

Conclusion

In this chapter, the authors reflected on the use of LEGO® Six BRICKS as a hands-on tool within a play- and problem-based approach to disrupt first-year education students' AoO and foster SDL skills. As a first step, this endeavour aimed to raise first-year education students' awareness of the perceptions of teachers and the teaching profession they bring to training. By requesting participants to construct and photograph their cubes before engaging them in writing narratives, the researchers aimed to promote critical reflection so that students would be able to identify possible gaps in their understanding. This is the start of the SDL process that should result in students' being more receptive to formal teacher-training and the progressive development of their professional identity. Creating an awareness of the pre-professional identity, informed by the AoO, offers space for growth and development in other facets of professional development. The findings validate the enhancement of communication skills, problem-solving abilities and personal reflection, not only on their choice to become teachers but also in conceptualising the kind of teacher they wish to be.

The data also highlight that student teachers are strongly influenced by several aspects and role-players ranging from family and former teachers to their experiences in the classroom. Using LEGO® Six BRICKS in this research emphasises that identity is not static and linear but that the journey to becoming a teacher is dynamic, multi-faceted and can, like LEGO®, be constructed, deconstructed and reconstructed in various ways. This argument is also true for the maturation of the professional identity. As teacher trainers guide student teachers to develop, reflect and grow, they learn and adapt. The outcomes indicate that although participants share certain perceptions, developing a teacher's professional identity is a personal and contextual matter dependent on SDL and personal reflection.

Chapter 9

Impact of drama-based pedagogy on self-directed learning skills and motivation in Grade 12 English Home Language learners

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Abstract

As English is the language of learning and teaching (LoLT) in South African classrooms, without it, necessarily being learners' first (mother-tongue), second or sometimes even third language, teaching pedagogies need to

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be found that can bridge the gap between learners' Home Language (HL) and the LoLT. Direct-teaching and teacher-centred pedagogies are no longer conducive to maximising learners' intake or production of a language and do not account for the development of self-directed learning (SDL) skills and motivation to learn (MtL), two very important aspects of language learning. Thus, a more 'inclusive' pedagogy, the drama-based pedagogy (DBP), was used to teach poetry as 'sample content' in the English Home Language (EHL) classroom to measure its impact on Grade 12 learners' SDL skills and MtL. This was done with a mixed-method research design which included pre- and post-DBP exposure SDL tests as the quantitative component of the study, as well as pre- and post-DBP exposure focus-group interviews, and observations, as the qualitative components of the study. The study's findings illustrated that challenging learners by expecting them to solve the problem of poetry analysis through critical engagement and drama-based activities positively affected both Grade 12 learners' SDL skills and MtL.

■ Introduction

This chapter introduces the problem that this research aimed to solve, the theoretical framework of the study in which the problem that inspired this research will be outlined, and the potential for the use of DBP to develop learners' SDL skills and MtL is justified. After that, the research design and analysis are explained with a discussion on the application of these and the results of the study, as well as a conclusion that defends the practicality of using DBP in the language classroom.

South African secondary school learners experience two challenges at a private school in the Gauteng province. Firstly, South African classrooms reflect that English is studied as a HL when it is sometimes not even learners' third or fourth language (Van der Walt & Evans 2019). The situation is exacerbated by the fact that learners receive little to no input in the target language (English, in this case) outside of the classroom setting because many live in African language-dominated areas where they use a variety of African languages to interact socially (Grosser & Nel 2013, p. 9). This essentially means, contradictorily, that learners are learning EHL without it being their HL. Van der Walt and Evans (2019, p. 17) expound this to the fact that the language is seen as the *lingua franca* and valued for the opportunities it may provide learners with after secondary education, as opposed to its practicality or usefulness in various South African sectors. Considering this reflection of South African EHL classrooms, Grade 12 learners may have below-average capabilities in the EHL subject, which could seriously hamper their academic achievement not only due to challenges such as 'limited English proficiency' (lEp) (Monyai 2010, p. iv) but also due to their lack of MtL and their inability to take responsibility for their own learning. Both formerly mentioned aspects (MtL and SDL) are essential in aiding learners to cope with an increase in academic workload, make academic progress, equip them with lifelong learning habits and prepare them for real-life demands (Guglielmino 2013; Mentz & Van Zyl 2018).

Secondly, South African teachers predominantly use direct-teaching methods that support a test-driven culture (Berry 2011, p. 98). Good scores in high-stakes tests and examinations, such as the South African Department of Basic Education's (DBE) National Senior Certificate (NSC), come at the price of active and critical learner engagement and the development of higher-order thinking skills (HoTS) in preparation for tertiary studies or the world of work (Berry 2011; Faizah et al. 2021).

In the language classroom, the literature study is particularly suitable for promoting HoTS, language proficiency, and active and critical engagement of learners via alternative pedagogies (Hellemann 2022).

Literature study as part of language curricula

According to Widdowson (1975, p. 1), the principal aim of literature study is to develop the capacity for individual response to language use. Widdowson (1975, p. 3) argues that developing this capacity to convey unique interpretations depends on awareness of literary discourse. Collie and Slater (1990, p. 3) agree with Widdowson that the study of literature plays an important part in language enrichment and in promoting personal learner involvement and add that literature texts are valuable, authentic material that provide cultural enrichment. Gillian (1999) believes that when learners are exposed to the rich language of a good literature text, it expands their awareness of the target language and their overall knowledge of word and grammar use. Furthermore, the complex, universal themes that literary texts present can encourage confidence and imaginative reflection about their own experience versus that of the writers living in different societies (Li & Fan 2019, p. 36). In linking with the argument of literature study serving the purpose of cultural enrichment, Hişmanoğlu (2005, p. 53) argues that not only is literature a tool for developing written and oral skills in the target language, but it serves as a window through which learners get to investigate the culture of the target language to construct their cultural competence. One can thus conclude that if literature is taught in a learner-centred way at the secondary school level, it can play a significant role in encouraging learners' SDL skills and MtL, which, in turn, will enable learners to take on a higher workload and work independently via self-motivation at tertiary and professional levels (Mentz & Van Zyl 2018).

Teaching in a learner-centred way to develop independent thinking becomes crucially important with the study of poetry, which is often regarded as 'the most sophisticated genre of literature, comprising a variety of contents that are narrative, lyrical and dramatic in nature' (Syed & Wahas 2020, p. 189). The study of poetry becomes more problematic when students lack proficiency in the target language. The South African DBE's *Curriculum and Assessment Policy Statement* (CAPS) for EHL (DBE 2011a, p. 14) acknowledges that it is never easy to teach literature and states that it can only successfully be done when learners are actively engaging with texts and invited to share their personal, thoughtful and honest interpretations. This implies that caution should be taken when teachers project their own interpretations of literary texts onto learners and rather create opportunities for meaningful learner participation. Because interpretation is subjective, every learner should be encouraged to search for meaning and feel safe to share their views and understanding.

The purpose of teaching poetry as a genre (DBE 2011a) and individual poems as creative texts is to:

> [*S*]how learners how language can be used with subtlety, intelligence, imagination, and flair. This means taking a close look at how text is created, manipulated, and re-arranged to clarify and emphasise what is being expressed. Such work might involve examining the presence or absence of imagery; what kind of imagery is being selected by the writer and why; sentence structures and paragraphing, or the layout of poems; choice of words, continuing motifs through the text; the use of symbol, sound, and colour where appropriate. A whole text means something, not just bits and pieces of it. (p. 14)

Therefore, pedagogies involving line-by-line text analysis should be avoided (Pushpa & Seyed 2014). In an examination-driven system where learners are coached to pass with good marks (Jordaan 2015, p. 154), they might find themselves ill-prepared for the demands of tertiary education and the world of work after secondary education because of a lack of SDL skills and meaningful learner engagement, as found in Strydom's (2019) study on the self-directedness of first-year university students. Thus, alternative pedagogies, such as DBP, which promotes SDL through active, meaningful learner engagement, should be emphasised better to prepare learners for their future after secondary education.

■ Drama-based pedagogy

It is important to note that while there is some overlap between the CAPS subject Dramatic Arts (DA) and the application of DBP to the language classroom, such as novel and play study, these are two completely different concepts. Dramatic Arts, 'prepared learners for entry into further studies for a possible career[s] in the drama (or related arts) field' (Ackerman 2021), as learners learn to express themselves with the use of props, lighting, breathing and articulation, among other DA aspects, to perform in front of an audience or on stage (DBE 2011b, p. 9).

On the other hand, DBP is described by Patall et al. (2015, p. 4) as 'a collection of drama-based teaching and learning strategies to engage students in learning' and is not necessarily for performance in front of an audience. Thus, the emphasis is not on learners' ability to develop and use performative skills but rather on how integrating drama into the classroom can aid learners in becoming more engaged in their learning and developing meaningful skills that might increase their academic ability. In support, Van Heerden and Veldsman (eds. 2021, p. 78) emphasise that incorporating DBP into classrooms can 'foster social skills, critical thinking, communication and comprehension skills, integrate knowledge and expand [learners'] horizons'. Drama-based activities, or 'conventions' as Baldwin (2015) calls them, can provide the teacher and their learners with a unique way to explore complex concepts and themes related to literature being studied. For example, Van Heerden and Veldsman (eds. 2021, p. 78) explain that using role-play, a well-known drama-based activity in which learners act 'in role' as friends sharing a sandwich, could teach learners something as complex as compassion. Thereafter, the activity might be 'tweaked slightly' to explore themes such as poverty which might be a prominent theme in the learners' CAPS-prescribed setworks. Drama-based pedagogy is also versatile as it can be utilised for both language-based subjects and content-based subjects, such as Biology (Life Sciences) and History (Patall et al. 2015, p. 4).

However, the benefits of using DBP in language education have been realised for more than three decades (Dunn & Stinson 2011). Some of these benefits, both general and language-specific, are highlighted by Kobayashi (2012, p. 30) and Uysal and Yavuz (2018, pp. 377–378):

- measured an increase in learners' confidence and creativity.
- promotes cooperative learning (CL) and, as a consequence, trust and acceptance.
- are supportive learner autonomy.
- encourages authentic language use.
- learnt new vocabulary through rote repetition new vocabulary.
- noted an increase in learners' motivation because of their heightened confidence using and interacting with the target language in a fun and interesting way.

Furthermore, DBP can be used in collaboration with language learning theories, such as Vygotsky's (1978) *social-constructivist theory* (SCT) and the *reader-response theory* (RRT), as well as the approaches suggested in the CAPS for EHL Grades 10–12 (DBE 2011a) for teaching languages: The communicative approach, text-based approach and process approach. This is because DBP requires the teacher to adopt a facilitative role in learners' language learning and exploration. Additionally, both Vygotsky's

(1978) SCT and the RRT acknowledge the learner and their social background as part of the learning process, as the former theory considers the learner's socio-cultural background as the basis from which they make meaning in language learning, and the latter theory considers the learner's experiences as part of the process when making meaning of a text while reading. The RRT, in particular, is described by its original theorist, Rosenblatt (1978), as a 'transaction'. Amer (2003, p. 68) simply explains that this 'transaction' is the ability of the reader to make meaning of a text through self-contraction, using one's own beliefs, values, expectations, and assumptions to reflect on and create their understanding of a text. Spirovska (2019, p. 23) further elaborates that in this way, the reader has the ability to change the text (based on who they are) and shares a similar role to the author of the text in terms of designing the text's intended message.

Either way, acknowledging the learner as part of the learning process is extremely important, especially when making use of the DBP, as drama-based activities are not meaningful if they do not relate to real-life examples and learners cannot express their real-life lived experiences (Patall et al. 2015, p. 4). Thus, the teacher has to be able to relinquish their role as the sole information giver and allow for learners' expression of their ideas in an authentic way in order for them to realise the benefits of making use of the DBP in the language classroom. Moreover, making use of DBP has the capacity to develop HoTS such as evaluation and analysis, which are not only skills of a self-directed learner but are also used in the learning of poetry because learners are placed in the context of the literature they are studying (Romylos 2020, p. 11). As a poetry-specific example: Learners are required to study a poem in which the speaker expresses their grief about the passing of a loved one. Writing 'in role', learners might write a diary entry from the perspective of the speaker of the poem after the teacher has scaffolded the context and content of the poem. The benefits of this type of drama-based activity are twofold: (1) the development of analysis skills, as learners are required to analyse the poem with regards to, for example, diction use, imagery and message, and (2) the development of writing skills. This example also illustrates the adaptive nature of DBP and its relative activities. To better understand DBP's adaptability, Table 9.1 explains the mechanics of each drama-based activity selected for the poems used in this study. However, it is important to note that many other drama-based activities have not been mentioned in this study (cf. Baldwin 2015).

Despite this short list of adaptive and interesting drama-based activities, teachers often marginalise using poetry as a promotional tool to increase learners' 'linguistic and cultural knowledge' (Gönen 2018) and teach it the same way they were taught: line-by-line analysis (Gönen 2018). Pushpa and Seyed (2014) emphasise how unfortunate this is, as poetry can increase

TABLE 9.1: Drama-based activities and their explanations used in this study.

Drama-based activity	Explanation of activity's mechanics
Performance carousel	Learners perform a very short scene from a text in groups. All groups have the same amount of time to perform (30 s to 1 min, for example) and must freeze as soon as their scene has been performed so that the next group knows when to begin their performance. Once the entire class, or all groups, have performed, the class 'melts' to the floor the same way a carousel might slow in motion and then stop when switched off. Alternatively, each group might 'melt' to the ground in slow motion after their performance, and once completely seated and still, the next group may begin their presentation. Used for poetry, a teacher might allocate a stanza to each group and facilitate its brainstorming until each group is ready to dramatise each stanza of the poem after the other.
Sculpting	In a group of learners, a 'sculptor' is chosen to 'mould' the other group members into a still image that captures the essence, theme or subject of a section of text or scene. The sculptor might verbally direct other group members or physically 'mould' them into a certain position. In the activity's application to poetry, teachers might allocate a stanza or line of poetry to a group. By the end of the activity, the entire poem can be viewed as some kind of 'sculpture gallery'.
Essence machine	• Learners stand in a circle or around the space to be used as the 'stage'. Each learner enters the space and performs a short, continuous movement, phrase or gesture that links to or portrays any given moment in a text. For example, in a poem about war, a learner might pretend to might role-play shooting a rifle/gun, while another might imitate detonated bomb sounds. While learners' movements, gestures and phrases may differ, they should collectively demonstrate a summary of the text using their movements, gestures and phrases for the teacher to evaluate. • The teacher may control the machine with a 'remote' and slow down or speed up its pace or increase or decrease the volume of the machine for dramatic effect
Choral verse	Learners speak in unison for dramatic effect. Movements that match the words may be added.

Source: Baldwin (2015).

learners' motivation to communicate in the target language when discussing, for example, the poem's theme. Thus, the adaptability of DBP has the capacity to develop learners' MtL, which can make all the difference in language teaching and learning, and, subsequently, their SDL skills (Tohidi et al. 2019, p. 26).

■ Self-directed learning

A well-known definition of SDL is provided by Knowles (1975; cf. ch. 1 of this book):

> A process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes'. (p. 18)

Knowles (1975) further provides the following characteristics, among others, of a self-directed learner:

- Sets clear learning goals.
- Self-monitors their own learning process.

- Evaluates the outcomes of their own learning.
- Works autonomously.
- Self-motivates.
- Is curious.
- Learns by taking the initiative.

These characteristics are aligned with both what the CAPS (DBE 2011a, p. 14) envisions for the study of poetry and the mentioned benefits of integrating DBP into the language classroom. However, SDL skills and characteristics cannot be developed 'instantly' but are rather, according to Grow (1991, p. 130), developed in stages. Grow's (1991) model of SDL is as follows:

- **Stage 1:** Little to no SDL skills can be observed in the learners and learners are over-reliant on the teacher as the sole information giver.
- **Stage 2:** SDL skills can be observed generally, as learners are open to the idea of being motivated and guided through learning activities.
- **Stage 3:** Teacher facilitates group discussion in which learners are involved and are active 'role-players' in their own learning. Some learners might even conduct their own research and augment their own learning.
- **Stage 4:** Teacher acts as a consultant while learners identify and coordinate their own learning goals as they are entirely self-directed.

As a result of the test-driven culture of South African classrooms (Jordaan 2015), it might be that learners may only be in Stage 1 of Grow's (1991) SDL model. Motivation also plays an integral role in learners developing SDL skills (Beckers, Dolmans & Van Merriënboer 2016). At Stage 2, teachers motivate learners to believe in their own capabilities to reach their learning goals. Thus, South African learners may develop or display the characteristics of a self-directed learner mentioned by Knowles (1975) before should the teacher acknowledge that increasing learners' MtL is a significant part of developing learners' SDL skills. To start this process, however, one way to identify the SDL stage that learners might be in is to task learners with completing Williamson's (2007) self-rating scale of self-directed learning (SRSSDL) questionnaire, which was used for this study. The correlations between this questionnaire and both DBP and MtL can be found in some of the questionnaire's twelve categories:

- I consider teachers as facilitators of learning rather than providing information only, I can maintain self-motivation. (Awareness area)
- I participate in group discussions, I find 'role-play' is a useful method for complex learning, I find interactive teaching–learning sessions more effective than just listening to lectures. (Learning strategies area)
- Interacting with others helps me develop the insight to plan further learning. (Interpersonal skills area)
- I keep an open mind to others' point of view. (Learning activities area)

Drama-based pedagogy may be conducive to developing learners' SDL skills and MtL because of these connections. Another important aspect of SDL, however, is reflection (Kemp, Baxa & Cortes 2022), as learners need to be able to reflect on their process of learning with reference to achieve their learning goals. Therefore, the researchers decided to add a reflection aspect to the drama-based activities in which learners were asked to reflect on other groups' presentations, where necessary, and communicate how they felt other groups dramatised certain stanzas of the poems used for this study. Drama-based pedagogy, therefore, creates opportunities for learners to engage in SDL to gain more confidence in their ability to make meaning of texts and to apply new knowledge when confronted with analysing new texts.

This study focused on Grade 12 EHL learners who are challenged to study English literature at the HL level, while English is not their HL. Being confronted by the problem of making sense of prescribed poems, this study aimed to determine the impact of DBP on the promotion of SDL and MtL in Grade 12 EHL learners.

Research design

A mixed-method design was chosen as it provides a more complete understanding of the data related to the research questions and problems instead of using singular designs such as the qualitative or quantitative approaches on their own (Wisdom & Creswell 2013). This 'more complete understanding' that the mixed-method design provides is attributed to the fact that the intention is to find multilateral relationships between the qualitative and quantitative data (Smith & Shorten 2017, p. 74). Thus, this design is fitting for this study as the researchers intended to identify and report on the relationships between DBP, SDL skills and MtL in Grade 12 EHL learners. Thus, a convergent parallel design was used to measure the impact of DBP on Grade 12 EHL learners' SDL skills and MtL, as the qualitative data and quantitative data were collected simultaneously to be combined later (Edmonds & Kennedy 2017, p. 181).

The study's quantitative data, Williamson's (2007) SRSSDL, were collected at the same time as the study's qualitative data, which were focus-group interviews and observations. However, both were repeated and collected twice. Once before, the learners were exposed to drama-based activities related to the poems selected for the study and prescribed in the Grade 12 CAPS curriculum, and once after learners' exposure to DBP. This was done as a pre- and post-process before and after a five-week EHL class attendance period in which the learners engaged in drama-based activities relative to the following prescribed poems from *Imagined Worlds: An Anthology of Poetry* (eds. McIntyre, Olivier & Varga 2015) – 19 selected by the South African Independent Examination Board (IEB): *Performance carousel* for 'Nightsong City' by Dennis Brutus, *sculpting* for 'Touch' by Hugh Lewin, *essence machine* for 'Portrait of a Loaf of Bread' by Mbuyiseni Oswald Mshali and *choral verse* for 'The Cry of South Africa' by Olive Schreiner.

These poems and the drama-based activities assigned to them were selected after the researchers analysed the texts regarding their specific forms, figurative language, diction and messages, among other poetic devices, and chose drama-based activities to help the learners understand the poems better. For example, in the poem 'The Cry of South Africa' by Olive Schreiner, the line 'Give back my dead!' is repeated and emphasised using the exclamation mark. Thus, choral verse (speaking in unison) seemed the most appropriate option for this poem, as it would aid the learners in understanding the angry tone of the speaker, especially while speaking in unison and screaming the line 'Give back my dead!', as opposed to a passive drama-based activity such as writing-in-role. Furthermore, other prescribed poems selected by the IEB for 2022 included, for example, 'Ulysses' by Alfred Tennyson. Considering the length of the poem (70 lines) and the historical context based on Greek mythology, this poem would take time to analyse and assign a drama-based activity because of the limited EHL periods and other EHL content that needs to be taught (Shakespeare, novel study, etc.). Nevertheless, these pre- and post-practices were done to measure the impact of DBP on Grade 12 learners' SDL skills and MtL, as the data were first analysed separately and then later combined to identify relationships between the qualitative and quantitative methods. The impact was measured through an analysis of the study's results in which learners developed skills related to DBP, SDL skills and an increase in their MtL.

■ Methodology

Within the mixed-method research design, pragmatism underpinned the research paradigm because it accounts for the use of both qualitative and quantitative methods and rejects the idea of using one method, either qualitative or quantitative methods, separately. This is because, when using both qualitative and quantitative methods simultaneously, the focus is shifted from the data collection method, as with qualitative or quantitative research designs, to the research problem (Creswell 2003; Frey 2018). Thus, pragmatism was suited to the study, as both quantitative (SRSSDL – pre- and post-test questionnaire) and qualitative (pre- and post-focus-group interviews) were used. Furthermore, to achieve triangulation in the study, the researchers conducted structured observations via spot checks during the learners' engagement in drama-based activities to support the data collection process and ensure the reliability of the findings. As a reference point to the reader, Williamson's (2007) SRSSDL questionnaire was used to measure the Grade 12 EHL learners' SDL skills before and after exposure to DBP through poetry teaching and learning, and the focus-group interviews (for which learners were divided into groups of five) were used to identify learners' perception of their MtL before and after exposure to DBP through poetry.

Sampling and data analysis

Non-probability purposive sampling was chosen for the study, which is used by researchers that have a particular purpose in mind for the study (Maree & Pietersen 2016, p. 197). Thus, the participants (20 in total) had to meet certain criteria, such as being in their last year of secondary school (Grade 12) and taking EHL, for the researchers to identify the impact of DBP on Grade 12 EHL learners' SDL skills and MtL. However, the members for the focus-group interviews (five per group) and each drama-based activity were selected randomly to observe and receive a true reflection of the learners' behaviours, thoughts and feelings that were not influenced by being in groups with their friends. The learners gave informed consent to participate.

As aforementioned, both Williamson's (2007) questionnaire and the focus-group interviews were analysed before and after the learners' exposure to DBP. They were compared to indicate any change in the Grade 12 EHL learners' SDL skills and MtL because they engaged in drama-based activities. However, the quantitative data (SRSSDL pre- and post-questionnaires) were processed by a qualified statistician at the North-West University (NWU) to identify the learners' level of SDL before and after their exposure to DBP, as well as the reliability of the questionnaire, among other things later discussed in the 'Discussion of findings' section of this chapter.

Oppositely, the focus-group interviews were recorded, transcribed verbatim and uploaded into ATLAS.ti™ (Version 8.3.1, Scientific Software Development GmbH) by the researchers. They then assigned self-created codes inductively (identified from the data) to the data to identify common themes and relationships between the data and answer the research questions. Finally, for the structured observations as the final aspect for the triangulation of the data, the researchers made notes during the learners' engagement with the drama-based activities at random times (spot checks) so that learners were caught unawares, and the researchers could truly reflect on their behaviour during the drama-based activities. Spot checks were also conducted as the researchers themselves facilitated the drama-based activities. According to Grow's (1991) model, notes were made about the stages of SDL that the learners were in from the first activity to the last.

This meant that the researchers had to have predetermined questions to guide the structured observation process. For example:

- Which words, actions and gestures contribute to the learners' level of engagement with the drama-based activities?
- Is much help asked for during the activities? How does this contribute to identifying which stage of Grow's (1991) SDL model the learners are in?
- Are there aspects relative to the study's theoretical framework present? For example, the SCT, the communicative approach, et cetera?
- Which words, actions and gestures suggest the stage of Grow's (1991) model the learners are in?

The notes made in response to these questions were then cross-referenced to the data collected from the focus-group interviews, and finally with the results of the SDL questionnaires to answer the study's primary research question: *What is the impact of DBP on Grade 12 EHL learners' MtL and SDL skills*? However, the 'Discussion of findings' section will discuss all three of these data collection methods and their findings.

Discussion of findings

Learners' level of engagement with drama activities through classroom observations

While the researchers were observing the learners' level of engagement with the drama activities during the classroom observations, they appeared to enjoy the activities truly. They did not seem to be intimidated or overwhelmed by the activities at all. Most participants were observed to be slightly unsure about the first activity, but their confidence to engage in the drama-based activities increased from the first to the last. The learners were observed to be smiling, laughing, gesturing animatedly and sharing ideas, which reinforced the idea that DBP '[...] fosters [learners'] social skills, critical thinking, communication, and comprehension skills' (eds. Van Heerden & Veldsman 2021, p. 78) and 'focus on process-oriented and reflective experiences' (Patall et al. 2015, p. 4). Thus, for the learners to achieve the objective of the drama-based activity, they were required to think critically and communicate their ideas to their group members who in turn then had to reflect on the shared ideas and follow a procedure to 'get the job done'. Furthermore, Vygotsky's SCT and the RRT were prevalent in the observations. This is illustrated through the following example:

The activity assigned to the poem 'Nightsong City' by Dennis Brutus was a performance carousel. This required the learners to create actions and movements that represented the stanza and its lines (and poetic devices) which were assigned randomly to each group. ‘the harbour lights glaze over restless docks’ is what the second line of the poem reads, and the group given the stanza including this line decided to assign one learner to represent the ‘restless docks’ an another to represent the ‘harbour lights’. The learner representing the ‘restless docks’ rested on her haunches and swayed from left to right like a ship swaying on the ocean, while the learner representing the ‘harbour lights’ stuck her arms out in front of her and made waving motions with them from left to right. Learners not included in this demonstration were asked to reflect on the images portrayed in front of them and comment on whether the demonstration reflected the line of the poem included in the group-assigned stanzas. This reflection process was done during each activity, as it is a significant step in developing the learners’ SDL skills (Kemp et al. 2022). The reflection process led one learner, not included in the demonstration, to ask what the learner representing the boat was supposed to symbolise. When it was revealed that she was attempting to represent a boat to illustrate ‘the restless docks’, the former learner shared that she would not have done it in the same way but could now see how the learner representing the boat was trying to illustrate the ‘restless docks’ in the poem.

This reflection process indicated to the researchers (as observers) that the learners relied on their social and cultural background to make meaning of the world around them but also learnt from each other by interacting in social contexts, which supported Vygotsky’s SCT. Furthermore, the RRT was included in the demonstration, as the drama-based activity included the reader and their interpretation of the content they read. Characteristics from both Kobayashi’s (2012, p. 30) and Uysal and Yavuz’s (2018, pp. 377–378) reasons for using DBP in the language classroom were also observed; specifically, increase in creativity, confidence, non-competitive group participation, communication of ideas through authentic use of English, and inclusion and use of language skills such as reading, writing, reading and speaking.

Regarding learners’ MtL, it was observed to increase from the first activity to the last. While the learners appeared unsure and apprehensive about the first activity, their excitement for each drama-based activity increased. This was because of both internal motivational factors, such as drive or self-motivation (intrinsic motivation) and external motivational factors, such as parental interest in academics and teacher encouragement (extrinsic motivation). This increase in MtL because of the use of DBP is later supported by the verbatim quotes from the focus-group interviews in which learners mention that they were motivated by a general appreciation for the activity, the learning of poetry in a new and exciting way, and to avoid direct-teaching methods and the usual classroom setting.

Finally, regarding learners' SDL skills, the researchers observed that they took the initiative and were self-motivated in their engagement with drama-based activities. With specific reference to Grow's (1991) stages of SDL, the learners appeared to be in Stage 1 of Grow's SDL stages as they were over-reliant on the teacher to give explicit direction for their actions and exposed their test-driven nature as they were looking for a 'right way' to do the activity. However, because the DBP calls for the teacher to assume a facilitative role, the teacher facilitated the learners' learning and encouraged them to explore their ideas and use their critical thinking skills and creativity. This stance, opposite to direct-teaching methods where the teacher is the sole information provider, appeared to encourage learners to move from Stage 1 of Grow's (1991) SDL stages to Stage 2, as they were 'open to motivation and guidance from the teacher'. Thereafter, and through engaging in more drama-based activities, the learners moved into Stage 3 of Grow's (1991) SDL model because they only needed slight facilitation from the teacher and, perhaps for the first time in poetry learning, enjoyed themselves immensely. Stage 4, the final stage of Grow's (1991) SDL model, was achieved in the last few drama-based activities, as the teacher had only to consult with the learners in their groups about their coordinated learning goals. However, the progression through these four stages is better explained through the focus-group interview sections described hereafter.

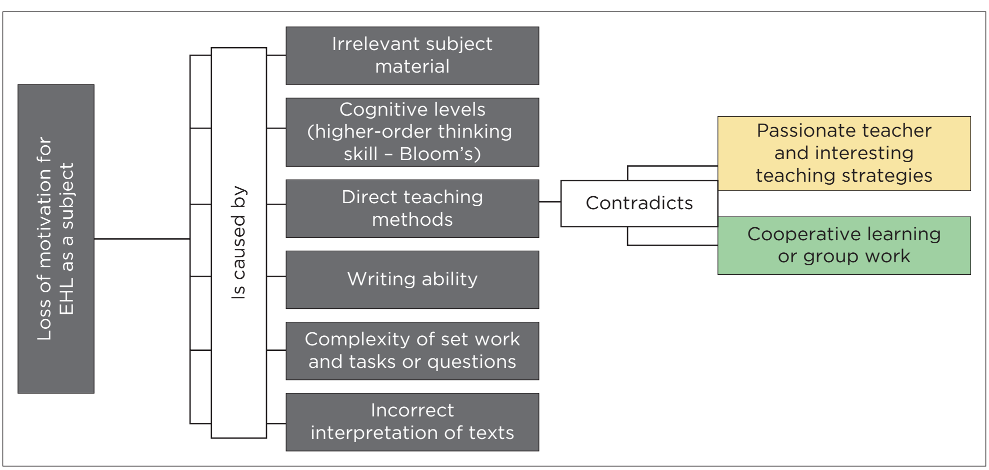
Focus-group interviews: Pre-exposure to drama-based activities

This step of analysing the data required the researchers first to understand the learners' perception of the EHL subject and its use in their daily lives, what motivated or demotivated their MtL in the EHL subject, and then more specifically, their perception of poetry teaching and learning before engaging in drama-based activities. This offered the researchers an interesting view of how the learners had experienced EHL teaching and learning up until that point and to justify the use of DBP in the language classroom.

Participants' perceptions of English Home Language and its relevance to their lives

What the focus-group interview data indicated after being uploaded and analysed through Atlas.ti™ (version 8.3.1, Scientific Software Development GmbH) (qualitative data analysis software) that participants used English for different reasons, such as (1) career opportunities, (2) communication, (3) practical use (such as the writing of emails) and (4) because it is the *lingua franca*. Furthermore, participants mentioned that they were both intrinsically and extrinsically motivated to study English. Intrinsic motivation was based on the desire to achieve professional or career goals, the inner drive to achieve good marks and a general interest in or enjoyment of subject content. Participants were extrinsically motivated as they feared failure or the lack of job opportunities as a result of below-average assessment marks, and because of passionate teachers and interesting teaching strategies, meeting parents' expectations and perceived benefits such as high-paying careers. However, with regard to the EHL subject, they mentioned more negative reasons that affected their MtL in EHL rather than how it was encouraged or increased. Thus, Figure 9.1 indicates the learners' loss of motivation for the EHL subject, as opposed to their reasons for the support and encouragement of their MtL.

According to Figure 9.1, representational of the learners' words from their focus-group interviews, the negative reasons for their loss of MtL in the EHL subjects include (1) the difficulty of set work (novels and poetry) and tasks, (2) limited writing skills, (3) direct-teaching methods, (4) the challenge of using HoTS (such as Bloom's evaluation), (5) irrelevance of subject content, (6) incorrect interpretation (of poetry, for example) and (7) the performance related to the maintaining good academic results. As more negative factors were mentioned than positive ones, this indicates that there needs to be a significant change in how the EHL subject is taught, especially considering that most of these negative factors seem to indicate, as aforementioned, that teaching is examination-driven. This is supported by the negative factors mentioned, such as direct-teaching methods, cognitive levels, assessment and performance, irrelevant subject material



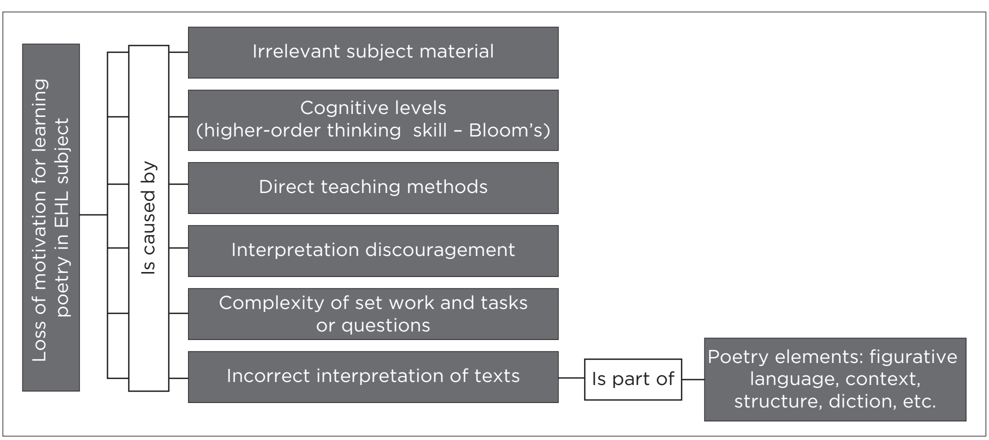
Source: Author's own work.
Key: EHL, English Home Language.
FIGURE 9.1: Loss of motivation for the English Home Language subject.

and incorrect interpretation. Thus, there is a disconnect between participants and subject material as everything is learnt to achieve the ultimate goal: to pass Grade 12. This is in no way conducive to lifelong learning and the development of SDL skills necessary for either tertiary education or the world of work after secondary school. Furthermore, as can be observed in Figure 9.1, the factors mentioned that are conducive to the learners' MtL in the EHL subject are CL or group work and passionate teachers or interesting teaching strategies. Drama-based pedagogy accounts for both, as the pedagogy links with PBL that considers the learner part of the meaning-making process (Kobayashi 2012; Uysal & Yavuz 2018), includes collaborative learning and promotes learning of content and the development of thinking skills. These mentioned benefits will encourage and develop learners' SDL skills and MtL, as they will become more confident in their language use (thus increasing their MtL) and become more independent in their learning (thus an increase in SDL skills). However, learners' perception of poetry teaching and learning was of specific importance, which is discussed hereafter.

☐ Poetry teaching and learning in the English Home Language subject

Like participants' perception of the EHL subject, more negative factors than positive factors were mentioned that affected their MtL poetry as indicated in Figure 9.2.

The negative factors included in Figure 9.2 mirror most of the negative factors discussed for the EHL subject, namely: (1) the complexity of poems and related tasks, (2) direct-teaching methods, (3) the challenge for higher-



Source: Authors' own work.
Key: EHL, English Home Language.
FIGURE 9.2: Factors that affect poetry teaching and learning.

order thinking (such as evaluation), (4) irrelevance of subject content, (5) incorrect interpretation (related to poetry) and (6) interpretation discouragement. Once more, this figure represents learners' inability to connect with and appreciate subject material and lack of enjoyment when having to learn. Especially relevant to the appreciation of poetry and the comprehension of the poet's message to answer examination questions, for example, is the ability to interpret the poem correctly (DBE 2011a, p. 14). While this skill, as with any, is developed with practice, the learners' words below indicate that poems were often interpreted for them while their own interpretations were discouraged:

> Interviewer: 'Okay. *(Long beat of silence)* Nothing else? *(Learners shake their heads)* Alrighty, um ... Have you ever been asked to give your interpretation of the poem as you read or study?'
>
> Participant 01: 'No.' [P03: 'Never'] 'No.'
>
> Participant 01: 'She would give us the poem, we had to read through it and then answer it. Only afterwards, she would tell us what the answers were supposed to be, and she wouldn't, like, pause and let us reflect on some of our answers. She would just rush through every poem, and it didn't give you a lot of time to connect your thoughts or like make corrections, and yeah [...].'
>
> Participant 01: 'Other than that, it was just you're given the poem, you read the poem, answer the questions.'
>
> Participant 04: 'Yeah, it was more just, "Here's the poem, here's what it's meant to be".'
>
> Participant 03: 'For me, there was no interaction or interpretation. We would just get the poems and that's what you needed to study and those are the questions and that's it.'

These direct quotes support Pushpa and Seyed (2014), who explain:

> [...] teaching poetry is for using it as a means to prepare the [*learners*] for some final exams [...] where [*learners*] just listen to the teachers; memorize certain words or grammatical points to get high grades instead of teaching [*learners*] independent thoughts and rational expressions. (p. 2014)

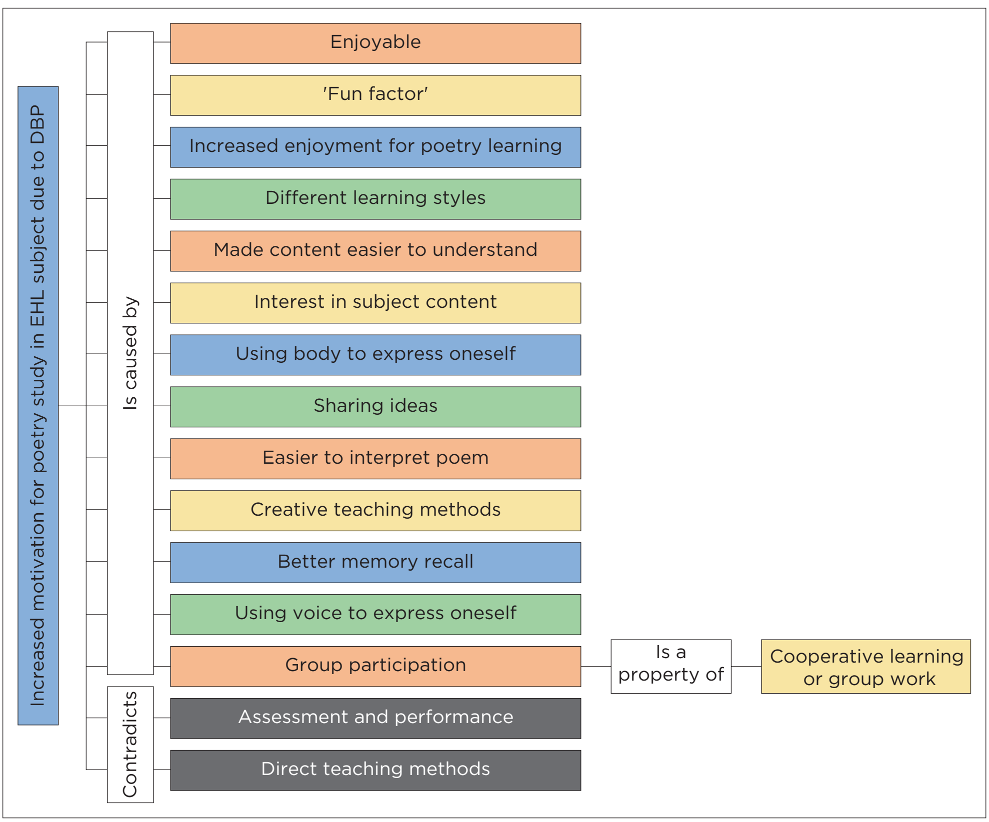
Thus, there can be no doubt why learners experience the study of poetry as irrelevant to their lives, why they struggle with the interpretation of poems, why higher-order cognitive engagement is not expected or taught and why activities are perceived as challenging. This is unfortunate, as Pushpa and Seyed (2014) indicate that learning poetry can increase learners' motivation because of its emotional content and increase learners' communication skills through discussions about the poem's content. Thus, using DBP to teach poetry can increase learners' MtL, and thus SDL skills, as it uses a multitude of different activities that encourage learners' interpretation and exploration of poetry, such as sculpting, for example.

The true impact of DBP on learners' MtL and SDL skills is reflected in the analysis of the focus-group interviews post-exposure to drama-based activities.

Focus-group interviews: Post-exposure to drama-based activities

Figure 9.3 illustrates the learners' experiences after their engagement with the drama-based activities.

Figure 9.3 illustrates the many positive experiences the learners experienced while engaging in drama-based activities, namely: (1) 'easier to interpret the poem', (2) 'sharing of ideas', (3) 'enjoyable learning experiences', (4) 'increased enjoyment for poetry learning', (5) 'accommodative of different ways of learning', (6) 'made poem's content easier to understand',



Source: Author's own work.
Key: EHL, English Home Language; DBP, drama-based play.

FIGURE 9.3: Increase in multi-task learning poetry in English Home Language subject as a result of drama-based play.

(7) 'generated interest in the subject content', (8) 'use of one's body and voice to express oneself', (8) 'engaged in group participation and cooperative learning', (9) 'increased memory recall' and (10) 'an appreciation for creative teaching methods'. Oppositely to the pre-drama-based activity exposure, the learners had more positive things to say about poetry learning and teaching than negative things. This indicates the ability of DBP to change the way learners engage with their subject material, which supports Van Heerden and Veldsman (eds. 2021) and Patall et al. (2015) who express that the pedagogy can encourage student achievement, persistence and engagement and provide opportunities to comprehend and understand their learning in a way that no other pedagogy can. With specific reference to the development of SDL skills, however, the increase in their MtL, as discussed in the observations and illustrated in Figure 9.3, aided learners in progressing from Grow's (1991) Stage 1 of SDL to Stage 4 of SDL, as expressed in Table 9.2 with a verbatim quote to prove.

Table 9.2 further exemplifies the advantages of making use of DBP in the language classroom, learners' SDL skills and MtL increased, which changes the usual way South African teachers teach and South African learners learn, that is, from a direct-teaching method classroom to a more collaborative, learner-focused, creative classroom. Furthermore, learners developed skills mentioned by Knowles (1975) and Jennett (1992) related to a self-directed learner:

- Sets clear learning goals.
- Self-monitors their own learning process.
- Evaluates the outcomes of their own learning.
- Works autonomously.
- Self-motivates.
- Is open to learning.
- Is curious.
- Identifies value in learning.
- Self-controls.
- Learns by taking the initiative.

Furthermore, the researchers also included a 'reflective aspect' to the learners' drama-based poetry learning, which is a critical step in developing SDL skills (Kemp et al. 2022), by asking them to reflect on their own and each other's presentations of the poems. They were asked and asked each other questions such as, 'Who are you?' and 'What are you doing?' Many learners stated that this was a helpful part of engaging in the drama-based activities and encouraged them to engage critically, cooperate and reflect, which Kemp et al. (2022) explain are significant features of developing SDL skills:

> 'I think it helped us understand, like, more at the end kind of finalise everything we just did. It tied it together to make sure everyone understood because if

TABLE 9.2: Learners' progression in Grow's (1991) stages of self-directed learning after engaging in drama-based activities.

Stage of SDL	Learners' responses
Stage 1: Learners require instruction from the teacher as the direct information giver and are wholly dependent on them	'I think the first time, I didn't know what to expect, so then I was a bit, like, apprehensive.' (Participant 05, female, post-interview 4) 'The first one, it was more, like, I was still like very quiet because I didn't know what to do. And I was, like, scared to pitch my ideas.' (Participant 01, male, post-interview 3) 'I wasn't really sure, I was a bit like despondent, thinking of, "'Okay, how could I do this? How can I do that?".' (Participant 03, male, post-interview 3) 'I think the very first activity I was very, very unsure of what exactly to do.' (Participant 02, female, post-interview 2)
Stage 2: Learners can be motivated and guided by the teacher and are self-directed in general terms, as they can identify the objective of a task	'[...] as time went on, I got much more comfortable [...].' (Participant 02, female, post-interview 2) 'Definitely more excited as we went through the activities because it's like it got more fun [...].' (Participant 01, male, post-interview 2) 'I started liking it. It changed as the activities went, but I came out liking poetry more.' (Participant 05, male, post-interview 1) 'But then as we went on, we had fun with it and towards the end, I think we all just enjoyed doing the whole activity.' (Participant 03, male, post-interview 3)
Stage 3: Learners are proactive in their learning and engage in discussions while supplementing their own learning with resources they could find independently. Some learners, however, may still need some guidance.	'I also contributed as much as they also contributed, you know, it as a team effort.' (Participant 04, male, post-interview 1) 'I think it's working with other people and working with people that you don't really work with. That's what I enjoyed.' (Participant 03, female, post-interview 3) '[...] working together with others as well, and integrating others' perspectives.' (Participant 05, male, post-interview 1)
Stage 4: Teacher acts as a consultant as learners can formulate their own learning goals and needs. Learners are thus fully self-directed.	This stage was included in the observation notes. While cooperating in their groups, the teacher gave instructions and the learners did as was asked with little guidance. The teacher 'consults' with them only when and if learners need assistance.

Source: Authors' own work.
Key: SDL, self-directed learning.

every group is doing something different, you might not understand what the other groups are doing. So, reflecting at the end really helps.' (Participant 02, female, post-interview 3)

'I think it's good to reflect because it gives open to new ways of interpretation. And with those new, like, ways of interpretation, you could come up with a method on how to understand something better to the extent that everyone in the group understands it better.' (Participant 04, male, post-interview 3)

'It just showed how everyone has a different idea and interprets it differently. So, when you ask, we're able to get from their point of view how they saw that part of the poem.' (Participant 04, male, post-interview 3)

Thus, using the DBP informed by the SCT, among others, is conducive to developing learners' MtL and their SDL skills. This is further supported by the quantitative data reflected in the next section.

The impact of drama-based pedagogy on learners' self-directed learning skills through the analysis of learners' pre- and post- self-rating scale of self-directed learning questionnaires following their engagement with drama-based activities

The quantitative data aimed to measure the impact of DBP on learners' SDL skills specifically, by making use of Williamson's (2007) SRSSDL questionnaire as a pre- and post-test. Thus, the learners took the test twice: once before and once after engaging in drama-based activities. The questionnaire consisted of 60 questions that learners would answer on a scale of 1–5 (the score 5 represented 'always', while the score 1 represented 'never'). Once all the scores are added, a maximum score of 300 and a minimum score of 60 would determine the learners' level of SDL. This range in score is split into three categories: Low, average and high. The *low range* is between 60 and 140, which indicates that learners need facilitation and guidance; the *average range* is between 141 and 220, which indicates that there are areas where learners need improvement for their SDL and the *high range* is between 221 and 300, which classifies the learners as having effective SDL (Williamson 2007).

When the learners took the questionnaire before they engaged with drama-based activities, the data reflected that 11 (55%) out of the 20 participants reported that they regarded themselves as being moderately self-directed, while nine (45%) were classified as having effective SDL. However, after engaging in the drama-based activities, the scores 'switched places': Nine participants were *moderately* self-directed, while eleven were *effectively* self-directed. This movement, while minimal, is statistically significant as the Pearson Chi-square value was 0.064. The Cramér's *V*-value (φc), determined by the Pearson Chi-square (x^2) value, was 0.4, which indicates that DBP had a medium practical effect on learners' SDL levels. Furthermore, the *p*-value was determined to be 0.017, indicating a statistically significant change between the pre- and post-SRSSDL, as $p < 0.05$ is statistically significant. The use of the questionnaire and its values can also be validated, as Cronbach's alpha (α) was determined for each subsection of Williamsons' (2007) SRSSDL, which is included in Table 9.3.

TABLE 9.3: Cronbach's alpha analysis per Williamson's (2007) construct of self-rating scale of self-directed learning.

Cronbach's alpha (α) value	
Construct name	**Pre-test**
Interpersonal skills	0.713
Evaluation	0.541
Learning activities	0.667
Learning strategies	0.764
Awareness	0.681

Source: Author's own work.

TABLE 9.4: Self-rating scale of self-directed learning dependent *t*-test indicative of Cohen's *d* value.

Statistical value name and corresponding SDL category	Mean (pre-test)	Mean (post-test)	Cohen's *d* (practical significance)
Interpersonal skills	43.60	45.47	0.39
Evaluation	43.70	46.50	0.55
Learning activities	41.30	43.20	0.34
Learning strategies	44.15	41.30	0.32
Awareness	45.90	46.40	0.11
Total	**218.65**	**277.82**	**0.59 (0.586)**

Source: Authors' own work.
Key: SDL, self-directed learning.

These values illustrated that the questionnaire was reliable and trustworthy in reflecting the data of this study. Furthermore, dependant *t*-tests of the pre- and post-SRSSDL data indicated statistically significant changes before and after the learners engaged in drama-based activities. Table 9.4 illustrates the value difference between the pre- and post-SRSSDL.

The 'total' value indicated is a value of 0.59. In terms of the change in the pre-SRSSDL and post-SRSSDL tests, a value of 0.2 indicates a minimal change, 0.5 indicates moderate change and 0.8 a large change. Therefore, 0.59 indicates a moderate change and a medium (thus practically significant) effect, tending to the large effect that the learners perceive DBP to have on the increase or development of their SDL skills. This can especially be seen in the difference in the mean values (or Cohen's *d* value) between the pre-and post-questionnaires in the 'Evaluation' and 'Total' sub-sections of Williamson's (2007) SRSSDL. All values considered, the data reflect that incorporating DBP into the language classroom positively impacted learners' SDL skills.

Reflection on play-based learning for student engagement and the promotion of self-directed learning skills

The data generation indicates that incorporating DBP into the EHL classroom positively affects learners' MtL and SDL skills. This was illustrated through the observations, focus-group interviews and SRSSDL questionnaires. Thus, making use of the DBP informed by other theories such as Vygotsky's (1978) SCT, the RRT – which acknowledges the reader as part of the process when making meaning from a text (Mart 2019) – and the strategies included in the CAPS curriculum (the text-based approach, the communicative approach and the process approach) may change the way content is delivered and connected within the South African classroom. Not only will the development of MtL and SDL skills aid learners in traversing the world after secondary education, but it may inspire a true enjoyment for learning and, in this case, an appreciation for the art of literature. However, considering this pedagogy was only applied to the teaching and learning of poetry, the researchers cannot assume that this positive impact reflects across all the EHL content. Consequently, the limitations of the study are discussed hereafter.

■ Limitations

The researchers identified three limitations of the study: (1) the size of the population, (2) the discipline the study was applied to and (3) the willingness of the teacher to relinquish 'control' over their student during teaching and learning, and the wiliness of their students to express themselves dramatically following the teacher's facilitation and direction.

Firstly, the population size (*n* = 20) makes it impossible to generalise the data and represent all Grade 12 EHL learners, for example. The sample size is attributed to two things: Purposive sample (as the participants were selected for a specific purpose) and convenience (as one of the researchers works at the small school at which the study was conducted). Additionally, the learners come from generally middle- to upper-class households. As such, the data might have been easier to generalise if the study was conducted at a public school with learners of varying socio-economic backgrounds and at a school with more than one and larger-sized EHL classrooms.

Secondly, the study was only applied to the EHL discipline and, more specifically, the study of poetry. Thus, the data cannot represent the application of DBP to all EHL content or other English subjects such as English as a First Additional Language (EFAL) and cannot generalise the application of DBP to other subject disciplines such as history or biology. Thus, the study only represents the impact of DBP on Grade 12 EHL learners' SDL skills and MtL in the study of poetry.

Finally, to validly repeat the study and reap the benefits of DBP in the language classroom, the teacher has to be willing to do extensive research on DBP and its application in the language classroom while taking on a facilitative role. This might be difficult for teachers who predominantly use direct-teaching methods in their language classrooms. Furthermore, this pedagogy also requires learners to express themselves dramatically, which might be difficult for introverted learners and cause anxiety in expressing themselves in front of their peers. Therefore, while there is a 'fun factor' to using DBP, teachers must maintain focus during drama-based activities and be able to guide learners without explicitly instructing them about their dramatic actions and decisions. Consequently, learners must be willing to express themselves extrovertedly and share their ideas with their group members, should the drama-based activity require them to do so.

Conclusion

In language classrooms today, learners should not only passively receive knowledge and regurgitate this knowledge in high-stakes tests and examinations. Instead, teachers should move away from teacher-centred strategies and challenge learners with play-based learning to enhance their MtL and SDL skills.

This chapter explored the impact of DBP on Grade 12 EHL learners' SDL skills and MtL in a mixed-methods research design. From the qualitative and quantitative empirical investigations, it is clear that the implementation of DBP positively impacted poetry education in the Grade 12 EHL classroom at a private school in South Africa.

Although it was a small sample, and the findings cannot be generalisable, valuable insights could be transferred to other contexts and subjects to empower and equip students with MtL and SDL skills to cope with and become active participants in the global society in the 21st century.

Chapter 10

Educational robotics for playful problem-based learning: Using cultural-historical activity theory as a research lens

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Abstract

Technological advancement requires relevant teaching–learning methods and transformation of traditional teaching approaches to promote skill development for the 21st century and the Fourth Industrial Revolution (4IR) era. It is therefore essential for higher education institutions (HEIs) to prepare students for innovation and future challenges that may arise.

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In particular, educational robotics (ER) has generated great interest in diverse fields such as science, technology, engineering and mathematics (STEM). Educational robotics is also recognised as essential for developing digital skills, critical thinking and collaborative problem-solving, initiative, autonomy and computational thinking. Therefore, students must take ownership of their learning when they are introduced to ER and work together responsibly. However, it is unclear how ER can promote such abilities in a playful problem-based learning environment (PPBL). This chapter aims to provide insight into the study of ER for PPBL using third-generation cultural-historical activity theory (CHAT) as a research lens. A qualitative methodology was employed, and two cohorts were involved, namely the postgraduate certificate in education (PGCE) information technology (IT) students and fourth-year Bachelor of Education (BEd) IT students. Participants' narrative reflections and video recordings were collected and analysed. The study's outcome provided valuable insight regarding students' experiences and the need for self-directed learning (SDL) skills in a PPBL context.

■ Introduction

New developments, such as 3D-printing, nanotechnology, cloud computing and robotics, associated with the 4IR will significantly impact the world of work and society (Schwab 2016). In addition, the World Economic Forum (WEF) (2020, p. 36) highlights the top fifteen skills for the future, such as 'analytical thinking, innovation, active learning, complex problem-solving, critical thinking and analysis, and technology design and programming'. Technological innovation plays a major role in STEM fields and positively affects students' skills and abilities. In particular, ER has generated significant interest in STEM subjects, promotes student engagement and affects their personal development positively (Arís & Orcos 2019). Educational robotics is also recognised as essential for the development of collaboration, initiative, autonomy, creativity, systems management and computational thinking (CT) (Chang & Chen 2020; González & Muñoz-Repiso 2018; Schina, Esteve-González & Usart 2021). Several skills can be developed by applying ER in a playful learning environment. Playful learning environments, such as game-based learning (GBL), emphasise the importance of students' engagement in problem formulation and the design of games as they require high-level thinking and problem-solving skills in a creative way (Bressler & Annetta 2022).

However, it is unclear how ER can be contextualised to promote responsible learning in a formal, playful, and problem-based learning (PBL) environment. Consequently, this chapter aims to contextualise ER for PPBL by using CHAT as a research lens concerning education students who applied ER in an IT course. The purpose of this chapter was twofold. Firstly, to determine how CHAT can be used as a research lens to study ER for PPBL. Secondly, to explore how ER can promote essential skill development of IT education students in a PPBL context.

Theoretical overview

Educational robotics

Educational robotics is considered crucial for the future and focuses on students' active involvement in the planning and constructing of robot artefacts (Evripidou et al. 2020; López-Belmonte et al. 2021). It was first introduced by Seymour Papert, who envisioned a learning context 'which allowed interaction between learners and computers' (Papert 1980, p. 60) and enabled them to develop innovative thinking. Educational robotics is viewed as an advancement of Seymour Papert's LOGO, an educational environment and programming language with Piaget's constructivist view in mind (Papert 1980). It was initially developed for children and is based on the execution of a so-called 'turtle' according to specific programming commands. Furthermore, ER is based on the constructionist theory, which emphasises an active learning environment and collaborative learning (Evripidou et al. 2020). According to Ackermann (2001, p. 1), Piaget viewed constructivism as a theory that outlines children's thinking, knowledge-creation and activities over time. In contrast, Papert's constructionism focused on the learning and *making of artefacts*, and 'how these conversations boost self-directed learning [...] and facilitate the construction of new knowledge'.

Educational robotics is a multi-faceted approach that comprises the design, assembly and application of robots based on the principles of STEM (Kim et al. 2015). The aim of ER is to improve the learning experience through relevant technologies and pedagogies, as robotics offers learners opportunities to be actively involved in the learning process (Angel-Fernandez & Vincze 2018). Pedagogical approaches for ER focus on student-centred strategies such as problem- and project-based, inquiry-based, discovery and GBL (Jaipal-Jamani & Angeli 2017; Kim et al. 2015).

The advent of ER in education provides for the development of CT skills (see ch. 5) and helps students to excel in their subject areas (Chiazzese et al. 2018). Wing (2006, p. 2) considers CT as 'a fundamental skill' relating to how humans think and how they approach and solve problems, as based on the concepts of computer science. Students are required to practice CT abilities, such as problem abstraction, decomposition, algorithm design and pattern recognition (Wing 2006). Several scholars concur that ER is a suitable tool for developing students' CT skills (Chalmers 2018; Chiazzese et al. 2018). Additionally, the development of CT is one of the reasons for using ER in classrooms (Chiazzese et al. 2018).

Robotics has become increasingly popular in the educational field because it promotes the development of skills such as creativity, group collaboration, problem-solving and critical thinking that are necessary for demands of work in the future (Valsamidis et al. 2021). Therefore, involvement in robotics activities promotes students' high-order thinking and provides for the acquisition of new knowledge and skills as a result of programming robots (Di Battista et al. 2020; Valsamidis et al. 2021).

Unfortunately, teachers' lack of readiness to implement STEM educational programmes, their lack of knowledge about robotic technology and reluctance to use new digital technologies in the classrooms are challenges that hinder the effective implementation of ER (Anisimova, Sabirova & Shatunova 2020; Badia & Iglesias 2019; Chalmers 2018). Researchers claim that ER is essential for the professional development of in-service and pre-service teachers (González & Muñoz-Repiso 2018; Jaipal-Jamani & Angeli 2017). Therefore, HEIs must develop relevant opportunities and strategies to ensure that future teachers are well-equipped to incorporate robotics into their classrooms. Learning ER is vital in teaching practice, as it will assist students in acquiring digital and supportive skills for their future (Hadad et al. 2021). Moreover, the successful integration of ER requires that teachers and lecturers apply several approaches for implementing ER activities in the classroom; hence, the need for the study reported on here.

Educational robotics and playful problem-based learning

The integration of ER in playful learning approaches brings about transformation in teaching and learning. In this regard, Paaskesen (2020) aimed to provide a playful learning environment in traditional classrooms by inspiring teachers to implement such activities in several subjects. Elements of playful learning reveal the principles of social-constructivist learning theory (Piaget 1972; Vygotsky 1978), which deals with active learning where knowledge is socially created.

Scholars concur that ER tends to promote learning playfully and demonstrate students' involvement and collaboration in the learning process (Kalogiannidou, Natsiou & Tsitouridou 2021). Playful learning is an approach that assists students in exploring and engaging with their surroundings and interacting with their peers in formal educational contexts (Zosh et al. 2018). Furthermore, studies have shown that playful learning pedagogies produce better learning outcomes than more traditional teaching practices (Nørgård, Toft-Nielsen & Whitton 2017). In particular, playful learning enables students the opportunity to experiment, explore and express themselves (Edwards 2017). Therefore, a playful mode of instruction allows for meaningful and joyful learning, active engagement and interactive collaboration with peers to solve a problem or address a challenge (Zosh et al. 2018).

Scholars also claim that playful learning can create a favourable environment for students in higher education (HE) by developing essential abilities they may need in the future (Forbes 2021). Playful learning utilises several pedagogical strategies, such as PBL, to enable students to develop skills by exploring a real-world problem. Thorsted, Bing and Kristensen (2015, p. 63) consider play as a 'mediator for knowledge-creation in problem-based learning' in HE. Playful learning in a PBL environment is student-centred as it fosters students' natural curiosity when addressing an open-ended problem and exposes them to essential subjects that will shape their lives and future careers (Forbes 2021; Higueras-Rodríguez, Medina-García & Molina-Ruiz 2020). Similarly, playful approaches enhance student engagement, motivation and quality of learning experiences (Forbes 2021).

Professional development and self-directed learning

The adoption of robotics in teaching practice has increasingly gained popularity in educational fields, where it aims to promote the development of skills required by students (Valsamidis et al. 2021). Scholars claim that ER teacher-training is essential for the professional development of pre-service and in-service teachers (González & Muñoz-Repiso 2018; Jaipal-Jamani & Angeli 2017; Kim et al. 2015). Moreover, robotics training is becoming common in teacher-training institutions across the globe (Kim et al. 2015; Majherová & Králík 2017). Teacher-training institutions should therefore provide future teachers with opportunities to be well-equipped to incorporate robotics into their classrooms. The successful integration of ER requires that educators understand its benefits and consider the best pedagogical approaches for implementing ER in the classroom. Self-directed learning (SDL) is a vital skill that should be gained by pre-service teachers in order to move society forward in the era of science. Penprase (2018) argues:

> More than anything, the 4IR puts a premium on adaptability and in self-directed learning and thinking [...] requiring future workers to continuously update their skills and teach themselves about new technologies and new industries. (p. 220)

Educational robotics provides opportunities to develop SDL abilities. Self-directed learners can manage their own learning responsibly and apply appropriate learning strategies to achieve learning outcomes (Knowles 1975). Moreover, SDL is used to strengthen the self-monitoring and self-evaluation skills that are crucial for the growth of professional competence (Wong, Tang & Cheng 2021).

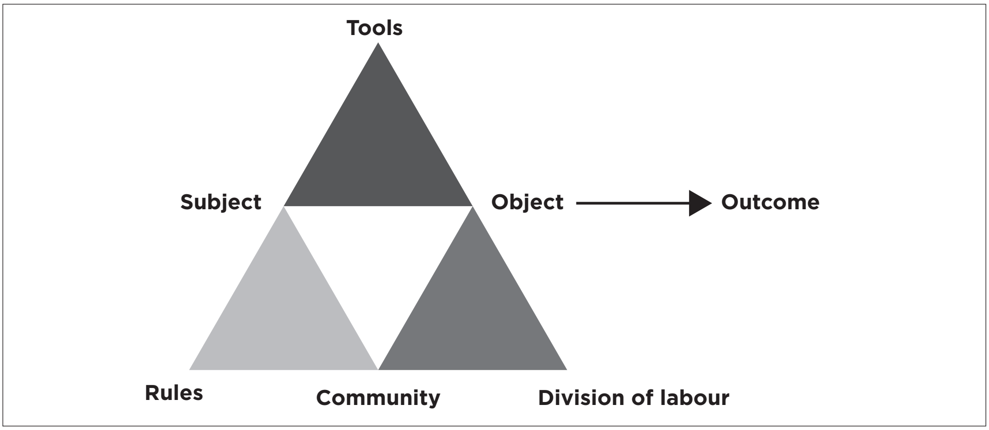
Openness to learning possibilities, self-concept, initiative and independent learning, responsibility for learning, love of learning, creativity and a hopeful outlook on the future are itemised as SDL's characteristics (Guglielmino 2013). Self-directed students inquire and seek new knowledge about which they are inquisitive and eager to take on new challenges and solve intricate problems (Knowles 1975). In a similar vein, higher-order thinking of students can be improved through ER (Bressler & Annetta 2022). Educational robotics was designed to improve teachers' confidence in teaching and learning programming languages (Jaipal-Jamani & Angeli 2017). Effective teacher preparation is a vital factor in promoting the self-confidence of teachers involved in teaching ER (Scaradozzi et al. 2019). In addition, the move to ER is essential as the South African Department of Basic Education's (DBE) 2021 draft of the *Curriculum and Assessment Policy Statement* (CAPS) for Coding and Robotics Grades R–9 has been compiled and planned to be formally implemented in schools in the next few years. As a result, teacher-training programmes should expose pre-service teachers to ER to support and prepare them to gain content and pedagogical knowledge and to provide professional development opportunities.

Cultural-historical activity theory

The CHAT originated from social constructivism and is mostly influenced by the work of Lev Vygotsky, a Russian psychologist, who emphasised the role of psychology in teaching and learning (Vygotsky 1978). Vygotsky believed that culture is an important aspect of children's cognitive development. Moreover, he referred to the core concept of the zone of proximal development (ZPD) regarding a learner's abilities and the potential development of a learner with the guidance of a teacher, adult or supportive peers (Vygotsky 1978).

Leontiev refined the activity theory (Leontiev 1978), while Engeström focused on active and ongoing interactions within socio-cultural settings (Engeström 2001). The activity system depicted in Figure 10.1 comprises six interconnected elements that work together to achieve the goal of the activity (Engeström 2001). Each of the elements (subject, object, tools, rules, community and division of labour) is outlined:

1. **Subject:** People involved in activities and who perform certain actions to achieve particular objectives.
2. **Object:** The activities being acted on to achieve a specific goal or outcome.



Source: Adapted from Engeström (1987, 2001).
FIGURE 10.1: The activity system.

3. **Tools:** The medium through which subjects perform an activity.
4. **Community:** Several people who work together and share the object of activity.
5. **Rule:** Formal and informal conventions and norms involved in an activity system.
6. **Outcome:** The goal that the subject aims to achieve.
7. **Division of labour:** Ways by which the subject manages to achieve the outcome.

Third-generation cultural-historical activity theory

The third-generation CHAT connects two activity systems working towards individual and collective goals (Engeström 2001). Cultural-historical activity theory views human activity as a complicated process involving a subject driven to achieve a goal and assisted by tools, which can be either physical or mental opportunities (Engeström 2009). An activity system is viewed as the unit of analysis in CHAT while simultaneously acknowledging the influence of other activity systems on the original activity system. Engeström (2001) highlights five guiding principles that reflect the essence of CHAT, namely:

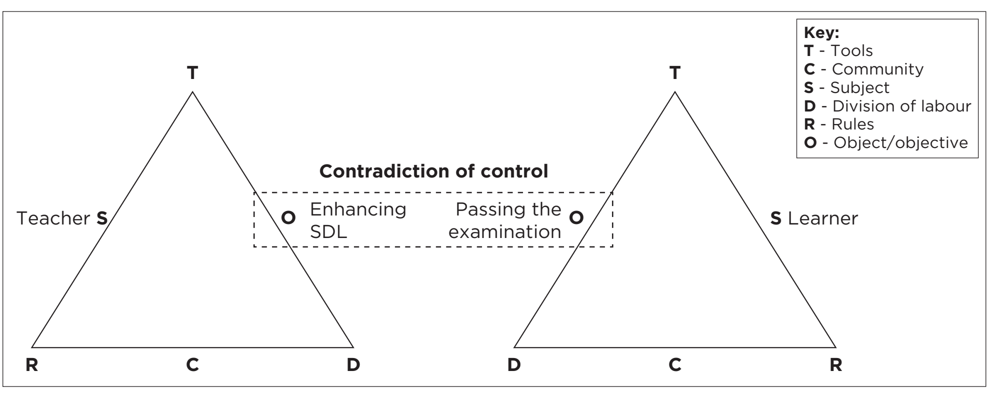
- The first principle emphasises that an activity system is communal, artefact-facilitated and object-focused.
- The second principle highlights various voices or dialogues with people who are involved in the activity system (e.g. subject, object and community).
- The third principle accentuates the feature of historicity as it requires a long time to form and transform activity systems.

- The fourth principle focuses on the role of so-called 'contradictions', which are essential drivers of growth and change.
- The fifth principle affirms the potential for significant change in an activity system.

The activity is an essential construct in CHAT in terms of its purpose and role in the interaction ('activities directed towards the object to achieve a goal') between actors or so-called 'subjects' (Engeström 1999, p. 9) with the aim to achieve a particular goal (metaphoric presentation of objects). The third-generation CHAT can be used as a research lens to assist in comparing and interpreting findings in activity systems (Mentz & De Beer 2019, p. 56). Figure 10.2 shows the application of CHAT on an interpersonal plane (teacher and learner) where the enhancement of SDL is the outcome of the activity system (De Beer & Mentz 2017, p. 11).

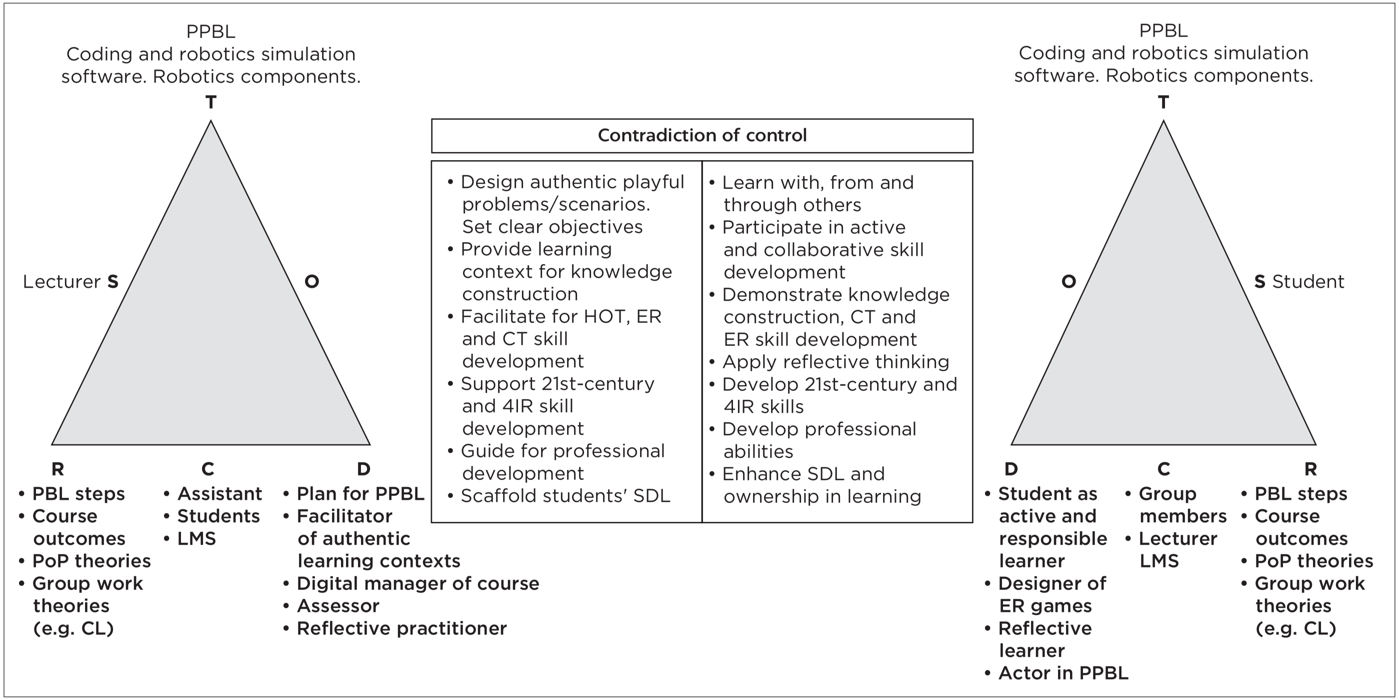
Although the activity system in Figure 10.2 focuses on enhancing SDL, it could be refined to provide an elaborate understanding of PPBL and ER. Carvalho et al. (2015, p. 2) applied the CHAT framework in the case of postgraduate students involved in designing severe games driven by a socio-cultural context. Based on the activity theory, the students considered educational games as 'part of a complex system that also includes human actors […] and the motives driving their [students'] interactions with the game' (Carvalho et al. 2015, p. 2).

In Figure 10.3, we illustrate how we applied CHAT as a conceptual lens to indicate border-crossing and object-driven activities and the deliberate interaction between the lecturer (facilitator) (Subject [in activity system one on the left]) and students (Subject [in activity



Source: De Beer and Mentz (2017, p. 11).

FIGURE 10.2: The use of cultural-historical activity theory on an interpersonal plane to enhance self-directed learning.



Source: Authors' own work.

Key: SDL, self-directed learning; 4IR, Fourth Industrial Revolution; HOT, higher-order thinking; ER, educational robotics; CT, computational thinking; LMS, learning management system; CL, cooperative learning; PoP theories (social constructivism, self-determination theory and self-directed learning; see ch. 2); PBL, problem-based learning; PPBL, playful problem-based learning. Learn with, from and through others (see ch. 4).

FIGURE 10.3: The use of cultural-historical activity theory in playful problem-based learning to compare two activity systems.

system two on the right]) where PPBL was applied with the aim of analysing students' mastering of coding and robotics as well essential skill development.

All outcomes of both activity systems are explicitly indicated with a verb as they involve 'a common word to describe an action, state, or occurrence' (The Concise Oxford English Dictionary 2004, p. 1605). Using verbs, therefore, serves a specific purpose in terms of emphasising the interrelated activities of both subjects and providing for operational action to achieve the outcomes. Such activities are also a function of time, as students are exposed to ER and develop essential skills over time. However, several internal contradictions may occur as the lecturer offered an opportunity for essential skill development while students were not introduced to ER previously. This is elaborated upon and discussed based on the study's emergent findings.

Playful problem-based learning intervention using educational robotics

Details regarding the intervention are outlined in this section.

Participants

Two cohorts were involved in this qualitative study, namely PGCE IT students as well as fourth-year BEd IT students (Table 10.1). For practical reasons, the students worked together in small groups to allow members to collaborate and contribute to the group. Members decided with whom they wanted to work. Each member had to be committed and willing to take responsibility for tasks involved in the robotics problem. The Research Ethics Committee of the Faculty of Education (EduREC) and the institutional gatekeeper approved the research project. Furthermore, all students who participated completed and signed informed consent to be involved in the research. Although two cohorts were involved, it should be stated that we

TABLE 10.1: Students who participated in this study.

Course for which enrolled	Number of students	Gender
PGCE (in IT)	8	Male: 0 Female: 8
BEd (in IT)	7	Male: 5 Female: 2
Total	**15**	

Source: Authors' own work, based on participant data.
Key: PGCE, Postgraduate Certificate in Education; IT, information technology; BEd, Bachelor in Education.

did not aim to compare these cohorts but rather to implement PPBL with the use of ER. Moreover, only a few students enrol annually for PGCE (full-time) or BEd in IT. As a result, we would like to allow all students to develop skills in ER, as it is essential for future demands.

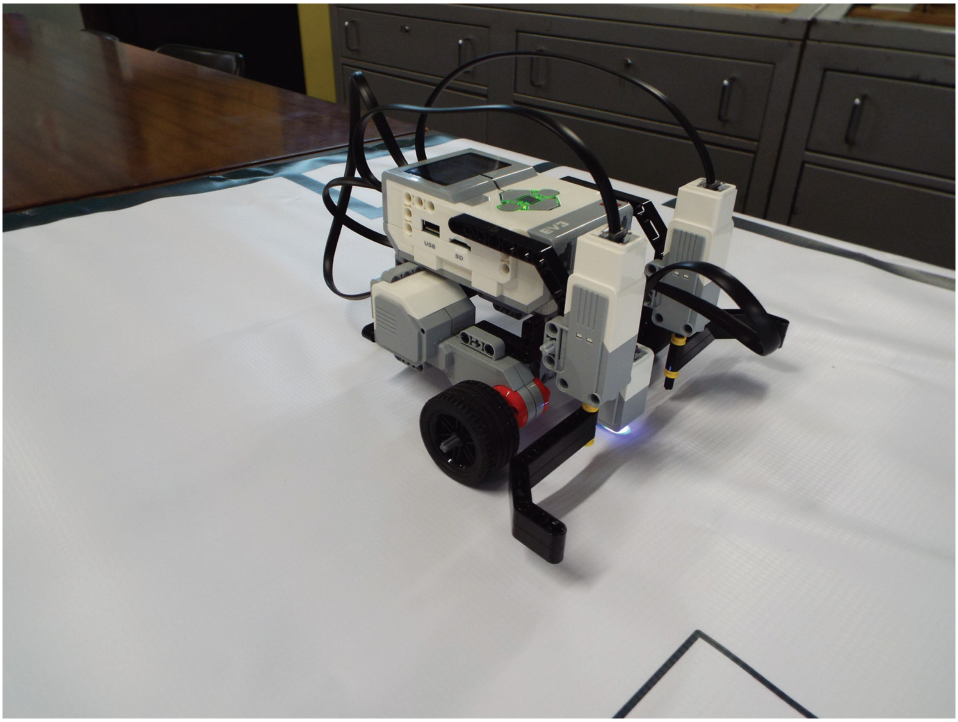
In terms of trustworthiness, the data analysis was conducted in such a way as to allow for precise and consistent interpretation of meanings as they emerged from participant's written feedback. In addition, video recordings of students' programming attempts as well as robot performance, based on the programming, were used as a means of triangulating findings and to indicate certain patterns of meaning.

Contextualised robot activities

Participants mentioned that they did not have prior knowledge of robotics. Consequently, it required detailed planning on the part of the lecturers to plan class activities and guide the students in their learning. Playful problem-based learning was applied as an active teaching–learning strategy in this research. The rationale was to focus on the activities involved in the process of playing and, therefore, to provide rich opportunities for learning as these emerged in collaborative and playful problem-solving (see ch. 4). Students worked together in groups while the lecturer planned robot activities on a learning curve to facilitate them. A brief introduction to LEGO® MINDSTORMS® EV3 (Figure 10.4) was given. The MINDSTORMS® core kit consists of a programmable brick, large and medium motors, as well as several sensors and supporting cables. Students were expected to build, program and execute robot movements, engage in critical discussion and reflect on their programming. Participants used the visual EV3 programming tool and transferred the code (program) to the robot using a USB port. Robot movements (based on the coding) were performed on a 12 cm × 12 cm vinyl mat.

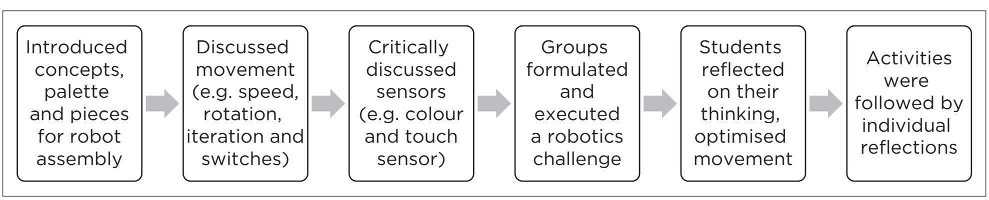
Teaching–learning activities, shown in Figure 10.5, were conducted over a period of four weeks.

Initially, students were provided with study materials to give some background on what programming in LEGO® MINDSTORMS® entails. This was followed by several activities where students collaborated in small groups. They were requested to build a simple robot (Riley Rover) to perform basic movements (e.g. rotation and iteration). The following week, group members combined robot movement using various sensors. After each activity, students assessed each other according to their contribution to the group.



Source: Photograph taken by Marietjie Havenga during student class activities on the North-West University Potchefstroom campus, published with permission from Marietjie Havenga.

FIGURE 10.4: LEGO® MINDSTORMS® EV3 robot.



Source: Presentation of the teaching and learning activities involved in this study.

FIGURE 10.5: Teaching and learning activities involved in coding and robotics.

As part of professional development, group members were challenged to formulate a class activity, which had to include building their own robot, movement and use of sensors as previously done in class. Instructions for this activity were the following:

- Design, build and move a robot to achieve certain objectives.
- Use several sensors, implement gears and also provide for push or pull actions.

- For each activity:
  - include photos (start and end position)
  - copy the visual programme code from LEGO® MINDSTORMS® to a Microsoft (MS) Word document
  - reflect on each robot movement
  - make a two–three-minute video of the movement as evidence with each activity.

After completing the assignments, students reflected individually and assessed themselves as well as their peers in terms of their responsibilities (individual and group), assistance, interaction and contribution to group work. In total, fifteen students participated in the reflections. They were prompted with questions to direct their thinking, as shown in Box 10.1.

Furthermore, students gave feedback on their challenges and how the group dealt with them. After four weeks, students submitted coding diagrams, videos and reflections on their group work and PPBL experiences on the LMS. Students' assignments and reflections were manually analysed using open coding (Saldaña 2016), and certain themes emerged.

Findings

Four themes emerged from the data. Selected exemplars related to a specific theme are included.

Authentic playful problem-based experiences

The students were challenged with open-ended robotics problems. Some responses were the following: '[We had to] work out an activity for learners to apply PBL and get to know the environment of [MINDSTORMS®]'

BOX 10.1: Reflective questions to direct students' thinking and collaboration.

1. What goals have your group set for the successful programming of the robot?
2. Explain how you managed your own learning processes while programming the robot.
3. Explain how you supported one another as group members with the robot's programming. What roles did each member play?
4. Identify important advantages of responsible group work when you programmed the robot.
5. Identify the problems that you or your group experienced when programming the robot.
6. Which sources did you consult to assist you in programming the robot?
7. Explain how you went about solving the programming problems.
8. Did you enjoy the challenge of programming the robot? Motivate your answer.
9. Indicate examples of computational thinking that you used when you programmed the robot.

Source: Authors' composition of reflective questions to prompt students, which form part of the data collection.

(Respondent 04, student, date unknown); '[*w*]e [...] set good goals for ourselves [...] we struggle with programming, so it makes us work slower than we wanted [...] but we get it right' (Respondent 05, student, date unknown). Students also consulted various sources to assist them in using sensors: '[*W*]e searched for a lot of information about colour sensors [...] especially on YouTube' (Respondent 05, student, date unknown); '[*I*] praised and valued everyone's effort. At first, we all built the car, but later we switched roles' (Respondent 14, student, date unknown). The value of addressing authentic problems was evident in students' feedback. They also valued group work and communication, as indicated in the next theme.

Active student collaboration and communication

Noteworthy is students' feedback about their active collaboration with PPBL. Some examples are: '[*A*]ll members worked well together and communicated about the problem and solutions' (Respondent 07, student, date unknown); '[*w*]e work very hard, and we have seen ourselves more determined, and it made us work very close together' (Respondent 01, student, date unknown). Students were motivated and realised that everyone had to contribute to the group in order to succeed. Group members emphasised the importance of enhancing each other's learning: '[*e*]veryone was helpful and did their part [...] helped with the code' (Respondent 07, student, date unknown); 'when someone doesn't understand, the rest will explain to everyone' (Respondent 08, student, date unknown); '[*t*]eamwork is what made the robot a success' (Respondent 14, student, date unknown).

> 'We didn't have anyone that just sat around and did nothing. Everyone made sure to help in the building process and in the coding process thus ensuring that everyone is responsible for the work that we did.' (Respondent 12, student, date unknown)

Positive and negative responses regarding group communication were noted: '[*W*]e are communicating well and sharing ideas' (Respondent 01, student, date unknown); '[*c*]ommunication is important to argue and in the end to deliver a better product' (Respondent 04, student, date unknown); '[*w*]e all played a similar role, however [Student T] was the programmer, and we all gave some ideas on which events should be taken'; '[*I*] was able to follow instructions on how to build the robot. I was able to understand different opinions when it came to discussing the program' (Respondent 13, student, date unknown). Unfortunately, some groups had some challenges: '[*W*]e struggled with communication, everyone just wanted to do [what they wanted] and not notice what the others were doing' (Respondent 03, student, date unknown).

Students' reflections on robot activities

Students reflected on their thinking and adjusted their programming to ensure the robot movements were performed correctly. Some responses were the following:

> '[*W*]e improved on the previous problem each time and then made adjustments to address the problems that arose' (Respondent 04, student, date unknown); '[*w*]e constantly adjusted the number of degrees until it was done correctly' (Respondent 06, student, date unknown); '[*o*]ur planning went well, and the robot did what we wanted it to do' (Respondent 05, student, date unknown); '[*t*]he colour sensor only worked on certain colours.' (Respondent 03, student, date unknown)

In addition, most groups experienced challenges with time management: '[*O*]ur pace was a bit slow because we had to restart our programme [...] we were a bit disappointed and made us want to work harder the next time' (Respondent 01, student, date unknown); '[*t*]he class time was a bit short, or we did not spend our time properly' (Respondent 08, student, date unknown); '[*w*]e worked efficiently and were able to complete the goal' (Respondent 04, student, date unknown); '[*i*]t is really nice that we work together [...] LEGO® [MINDSTORMS®] [are] fun' (Respondent 10, student, date unknown). In contrast, one student (Respondent 06, student, date unknown) mentioned that, although she participated, she considered robotics a waste of time, as she was very busy and could have been doing better things (Respondent 06, student, date unknown).

Essential skill development for the future

Digital technologies require lecturers to assist students in developing essential skills for the 21st century and the 4IR. The incorporation of ER was valuable for students: '[*W*]e had to think, and we brainstormed and came up with solutions' (Respondent 01, student, date unknown). Students initially experienced problems working with the various types of sensors. The coding, in particular, was a problem: '[*S*]truggled to make the colour sensor work, but everyone was thinking of solutions to get it right' (Respondent 03, student, date unknown); '[*p*]roximity sensor was a bit lacking; it wasn't exact with the percentages. Colour sensor wasn't accurate with the colours' (Respondent 14, student, date unknown). Group members also referred to important skills they developed: '[*W*]e had good reasoning ability and could use it to deal with error handling' (Respondent 04, student, date unknown); '[*w*]e had to research how to perform a rotation before we could implement it' (Respondent 04, student, date unknown); '[*c*]ontinue to improve it over and over, did it step by step' (Respondent 07, student, date unknown); '[*t*]here were pieces that were missing when we wanted to do the push/pull activity, we had to improvise [...] we didn't have an object to test the push/pull activity so we used wheels and some pieces the robot can perform its task on' (Respondent 14, student, date unknown). Reflection regarding their progress involved the following: '[*g*]ood progress and the longer we worked, the faster we got it. Good progression was shown' (Respondent 05, student, date unknown); '[*i*]t was nice to physically build the robot and to see how it fits together [...] we strengthened the robot [structure] and were able to test additional code and programs' (Respondent 08, student, date unknown). Development of skills was also indicated by Respondent 12:

> 'In the whole process of building the robot I made sure to take notes of the various factors that went into building the robot such as the design, the use of the different parts and the little errors in the coding process that we would run into. After making an error I would make sure to reflect on the error to find out if there was anything I could have done better in order to avoid some of the mistakes we made.' (Student, date unknown)

Regarding the development of CT, such as decomposition and algorithmic thinking, Respondent 12 stated:

> '[*T*]he robot needed to make use of the colour sensor and the motion sensor. So, we took them apart first and firstly added in functions for the colour sensor and made sure they work before starting with the next section of the motion sensors coding. After both were completed and tested separately, we went to work on adding them together to then complete the task.' (Student, date unknown)

Discussion

In the study reported here, we investigated how ER can promote skill development and SDL in a playful problem-based context. Among the findings were that students set specific learning goals, were curious and searched for relevant information regarding LEGO® robots, they learnt the MINDSTORMS® programming environment, they assisted each other (e.g. how to use several sensors) and ensured that everyone was actively involved in building and coding the robot. Participating students also persisted in their learning (a characteristic of a self-directed learner), as some groups struggled with the programming but got it right in the end. Group members emphasised that working responsibly together enabled them to succeed. Facilitation by the lecturer was crucial in scaffolding students. The findings align with Valsamidis et al. (2021), who argued that SDL promotes the development of skills such as creativity, group collaboration, problem-solving and critical thinking.

In terms of professional development, future teachers must develop relevant abilities and select appropriate strategies to incorporate robotics in their classrooms. Consequently, the students were challenged to formulate their own programming problem, plan a solution, use relevant components and deal with complexity. This is supported by Scaradozzi et al. (2019), who claimed that effective teacher-training is a vital factor in both the knowledge and the self-confidence of teaching ER.

Although it was initially difficult, most of them were interested and collaborated in this challenge. One group revealed that they had some problems with communication; however, most of the members were actively involved, shared ideas, argued about possible solutions and reflected on their thinking. One hurdle to overcome was students' time management, as some did not spend their time properly while others were able to achieve their goals. Students set aside time to reflect on their ER activities and learn from their mistakes to improve their thinking about the robot movement. Iterative cycles of programming and robot execution were essential to improve each group's performance. Group members considered their learning about programming and robotics as valuable for the future. They strengthened the robot structure, developed complex thinking (reasoning, logical thinking, judgement, decision-making and CT), dealt with error handling and debugging, learnt from their mistakes and critically reflected on their thinking. Bressler and Annetta (2022) argue that students' higher-order thinking skills (HoTS) can be improved through ER. The findings are also supported by Di Battista et al. (2020), who emphasise that involvement in robotics activities provides for acquiring new knowledge and skills as a result of programming such robots.

In addition, students developed CT skills, such as decomposition and algorithmic thinking (see ch. 5). Wing (2014) emphasises these skills are important for future development and society. The fun and playful element in PPBL were also prominent. Students were motivated and reflected that they enjoyed ER and experienced LEGO® MINDSTORMS® to be fun, as mentioned: '[I]t was nice to build the robot physically and to see how it fits together'.

Learning about ER is vital for the digital future, as stated by Hadad et al. (2021). Findings are supported by scholars who emphasise skill development in ER for the future (Schina et al. 2021). Complex problem-solving, active and innovative thinking, design and programming of solutions, and the use of active learning strategies (e.g. PBL and playful learning) are highlighted by several scholars, such as the WEF (2020), to be crucial for the 4IR. Consequently, ER mediates the learning for the 4IR as students develop as independent and self-directed learners.

Regarding the application of the third-generation activity theory in this study, the findings indicate that students enjoyed PPBL and several opportunities were provided to develop higher-order thinking, CT and the value of student collaboration to address the problems in ER. For example, students had to understand that the robot's components for input and output had to be attached in a specific way. They built and strengthened the robot structure, and this was followed by understanding the visual programming palette and applying programming code in a logical way to perform the robot movement. As part of this activity system, students (Subject[2]) demonstrated knowledge construction and the development of crucial skills and could take ownership of their learning. However, it is worth noting that one student mentioned that she considered robotics a waste of time, as she could have used it much better than doing two hours of robotics a week. In addition, some groups experienced difficulty in completing a weekly assignment on time. Furthermore, this indicates certain tensions in the activity system where the students experienced ER as coercive instead of an opportunity to develop skills for the future. It also emphasised enhanced scaffolding and guidance from the lecturer (Subject[1]) regarding group work and time management.

Reflective points, recommendations and limitations

Based on our findings, we highlight some important points and suggest some recommendations:

- Playful problem-based learning provides nuanced ways of learning and creative and innovative thinking and favours fun activities.
- Detailed planning and design of activities and scaffolding are essential to encourage students when solving complex problems and developing active learning abilities.
- Interpersonal skills, effective collaboration and group communication are crucial in PPBL.
- Students must be owners of their learning, be motivated and develop as self-directed learners.
- Educational robotics mediates learning and skill development for a challenging future and the 4IR.

The scope of the research is limited to IT students in the North-West University's (NWU) Faculty of Education, South Africa. The study consisted of a small sample size (15), making it difficult to generalise to HEIs. Further research is required to help scholars understand whether similar trends are evident elsewhere.

Conclusion

This chapter highlighted how ER could promote skill development in a playful problem-based environment. Third-generation CHAT was used as a conceptual framework to guide the researchers in understanding the border-crossing and object-driven activities between two activity systems where PPBL was applied. It was clear that most students enjoyed the application of ER in PPBL, and opportunities were provided for collaboration and the development of HoTS while addressing problems in ER. Students' experiences with ER offered the promotion of SDL when working with robots. Various reflective points were also mentioned. Unfortunately, only a small number of participants were involved in the research, and the findings cannot be generalised.

References

Foreword

Chmielewski, JG & Stapleton, MG 2009, 'The undergraduate research experience: It's not for everyone, students and faculty alike', *BIOS*, vol. 80, no. 2, pp. 53–58. https://doi.org/10.1893/011.080.0201

Geertz, C 1973, 'Thick description: Toward an interpretative theory of culture', in C Geertz (ed.), *The interpretation of cultures*, Basic Books, New York, pp. 3–30.

Hiemstra, R & Brockett, RG 2012, 'Reframing the meaning of self-directed learning: An updated model', viewed 20 June 2023, <https://newprairiepress.org/aerc/2012/papers/22>

Huizinga, J 1955, *Homo ludens: A study of the play element in culture*, Houghton Mifflin, Boston.

Sogunro, OA 2004, 'Efficacy of role-playing pedagogy in training leaders: Some reflections', *Journal of Management Development*, vol. 23, no. 4, pp. 355–371. https://doi.org/10.1108/02621710410529802

Tytler, R 2007, *Re-imagining science education: Engaging students in science for Australia's future*, Australian Council for Educational Research, ACER Publishing, Melbourne.

Veresov, N 2004, 'Zone of proximal development (ZPD): The hidden dimension?', in A Ostern & R Heila-Ylikallio (eds.), *Sprak som kultur – brytningar I tid och rum [Language as culture –tensions in time and space]*, vol. 1, Vasa Publishers, Richmond, pp. 13–30.

Vygotsky, LS & Cole, M 1978, *Mind in society: The development of higher psychological processes*, Harvard University Press, Cambridge.

Preface

Coopilton, M 2022, 'Critical game literacies and critical speculative imagination: A theoretical and conceptual review', *gamevironments*, vol. 17, pp. 222–273. https://doi.org/10.48783/gameviron.v17i17.196

Galbraith, J 2022, '"A prescription for play": Developing early childhood pre-service teachers' pedagogies of play', *Journal of Early Childhood Teacher Education*, vol. 43, no. 3, pp. 474–494. https://doi.org/10.1080/10901027.2022.2054035

Lapidow, E & Walker, CM 2022, 'Rethinking the "gap": Self-directed learning in cognitive development and scientific reasoning', *Wiley Interdisciplinary Reviews: Cognitive Science*, vol. 13, no. 2, a1580. https://doi.org/10.1002/wcs.1580

Manuaba, IBAP, No, Y & Wu, CC 2022, 'The effectiveness of problem-based learning in improving critical thinking, problem-solving and self-directed learning in first-year medical students: A meta-analysis', *PLoS One*, vol. 17, no. 11, a0277339. https://doi.org/10.1371/journal.pone.0277339

Palaniappan, K & Noor, NM 2022, 'Gamification strategy to support self-directed learning in an online learning environment', *International Journal of Emerging Technologies in Learning*, vol. 17, no. 3, pp. 104–116. https://doi.org/10.3991/ijet.v17i03.27489

Song, Y, Lee, Y & Lee, J-H 2022, 'Mediating effects of self-directed learning on the relationship between critical thinking and problem-solving in student nurses attending online classes: A cross-sectional descriptive study', *Nurse Education Today*, vol. 109, a105227. https://doi.org/10.1016/j.nedt.2021.105227

Chapter 1

Aker, M & Pentón-Herrera, LJ 2020, 'Smart literacy learning in the twenty-first century: Facilitating PBSL pedagogic collaborative clouds', in S Yu, M Ally & A Tsinakos (eds.), *Emerging technologies and pedagogies in the curriculum, bridging human and machine: Future education with intelligence*, Springer, Singapore, pp. 429–445.

Albanese, MA & Hinman, GL 2019, 'Types and design of assessment in PBL', in M Moallem, W Hung & N Dabbagh (eds.), *The Wiley handbook of problem-based learning*, Wiley, Hoboken, pp. 389–410.

Albanese, MA & Mitchell, S 1993, 'Problem-based learning: A review of literature on its outcomes and implementation issues', *Academic Medicine*, vol. 68, no. 1, pp. 52–81. https://doi.org/10.1097/00001888-199301000-00012

Ali, SS 2019, 'Problem-based learning: A student-centered approach', *English Language Teaching*, vol. 12, no. 5, pp. 73–78. https://doi.org/10.5539/elt.v12n5p73

Allen, DE, Donham, RS & Bernhardt, SA 2011, 'Problem-based learning', *New Directions for Teaching and Learning*, vol. 128, pp. 21–29. https://doi.org/10.1002/tl.465

Arnott, L 2016, 'An ecological exploration of young children's digital play: Framing young children's social experiences with technologies in early childhood', *Early Years*, vol. 36, no. 3, pp. 271–288. https://doi.org/10.1080/09575146.2016.1181049

Aziz, MA, Zain, AM, Samsudin, MAB & Saleh, SB 2014, 'The effects of problem-based learning on self-directed learning skills', *International Journal of Academic Research in Progressive Education and Development*, vol. 3, no. 1, pp. 135–146. https://doi.org/10.6007/IJARPED%2FV3-I1%2F694

Baran, M 2016, 'Teaching gases through problem-based learning', *Journal of Education and Training Studies*, vol. 4, no. 4, pp. 281–294. https://doi.org/10.11114/jets.v4i4.1498

Barker, B, Nugent, G, Grandgenett, NF & Adamchuk, S 2012, *Robots in K-12 education: A new technology for learning*, IGI Global, Hershey.

Barrows, HS 2000, *Problem-based learning applied to medical education*, Southern Illinois University Press, Springfield.

Barrows, HS & Tamblyn, RM 1980, *Problem-based learning: An approach to medical education*, Springer, New York.

Benadé, GP 2020, 'Implementing hybrid problem-based learning in mechanical technology to enhance pre-service teachers' self-directed learning', PhD thesis, North-West University, Potchefstroom.

Bestetti, RB, Couto, LB, Romao, GS, Araujo, GT & Restini, CB 2014, 'Contextual considerations in implementing problem-based learning approaches in a Brazilian medical curriculum: The UNAERP experience', *Medical Education Online*, vol. 19, a24366. https://doi.org/10.3402/meo.v19.24366

Bidokht, MH & Assareh, A 2011, 'Lifelong learners through problem-based and self-directed learning', *Procedia Computer Science*, vol. 3, pp. 1446–1453. https://doi.org/10.1016/j.procs.2011.01.028

Borhan, M 2014, 'Problem-based learning (PBL) in teacher education: A review of the effect of PBL on pre-service teachers' knowledge and skills', *European Journal of Educational Sciences*, vol. 1, no. 1, pp. 76–87. https://doi.org/10.19044/ejes.v1no1a9

Brassler, M & Dettmers, J 2017, 'How to enhance interdisciplinary competence – Interdisciplinary problem-based learning versus interdisciplinary project-based learning', *Interdisciplinary Journal of Problem-Based Learning*, vol. 11, no. 2, a12. https://doi.org/10.7771/1541-5015.1686

Caesar, MIM, Jawawi, R, Matzin, R, Shahrill, M, Jaidan, JH & Mundia, L 2016, 'The benefits of adopting a problem-based learning approach on students' learning developments in secondary geography lessons', *International Education Studies*, vol. 9, no. 2, pp. 51–65. https://doi.org/10.5539/ies.v9n2p51

Carrió, M, Agell, L, Baños, JE, Moyano, E, Larramona, P & Pérez, J 2016, 'Benefits of using a hybrid problem-based learning curriculum to improve long-term learning acquisition in undergraduate biology education', *FEMS Microbiology Letters*, vol. 363, no. 15, pp. 1–7. https://doi.org/10.1093/femsle/fnw159

Ceker, E & Ozdamli, F 2016, 'Features and characteristics of problem-based Learning', *Cypriot Journal of Educational Sciences*, vol. 11, no. 4, pp. 195–202. https://doi.org/10.18844/cjes.v11i4.1296

Chang, C, Chung, C & Chang, J 2020, 'Influence of problem-based learning games on effective computer programming learning in higher education', *Educational Technology Research and Development*, vol. 68, pp. 2615–2634. https://doi.org/10.1007/s11423-020-09784-3

Choo, SSY 2012, 'Scaffolding in problem-based learning', in G O'Grady, E Yew, K Goh & H Schmidt (eds.), *One-day, one-problem*, Springer, Singapor, pp. 167–184. https://doi.org/10.1007/978-981-4021-75-3_8

Chuan, TY, Rosly, NB, Zolkipli, MZB, Wei, NW, Basheer, MAB, Ahamed, MABB, Mustapha, NAB, Salam, A & Zakaria, Z 2011, 'Problem-based learning: With or without facilitator?', *Procedia Social and Behavioral Sciences*, vol. 18, pp. 394–399. https://doi.org/10.1016/j.sbspro.2011.05.057

Clark, I 2012, 'Formative assessment: Assessment is for self-regulated learning', *Educational Psychology Review*, vol. 24, no. 2, pp. 205–249. https://doi.org/10.1007/s10648-011-9191-6

Corrêa, AGD & Martins, VF 2016, 'Methodology applied problem-based learning in teaching HCI: A case study in usability evaluation of an online course', in D Fonseca & E Redondo (eds.), *Handbook of research on applied e-learning in engineering and architecture education*, IGI Global Publishers of Timely Knowledge, Hershey, pp. 159–177.

Costa, SA 2017, 'Puzzle-based learning: An approach to creativity, design thinking & problem-solving. Implications for engineering education', *Proceedings 2017 Canadian Engineering Education Association (CEEA17) Conference*, 04–07 June, University of Toronto, Toronto, Canada.

Dahms, ML & Zakaria, HL 2015, *Institutional capacities in e-learning and problem-based learning at universities and university colleges in Tanzania and Ghana*, Department of Development and Planning, Aalborg University, Aalborg.

Darling-Hammond, L, Flook, L, Cook-Harvey, C, Barron, B & Osher, D 2020, 'Implications for educational practice of the science of learning and development', *Applied Development Science*, vol. 24, no. 2, pp. 97–140. https://doi.org/10.1080/10888691.2018.1537791

De Graaff, E & Kolmos, A 2003, 'Characteristics of problem-based learning', *International Journal of Engineering Education*, vol. 19, no. 5, pp. 657–662.

De Simone, C 2014, 'Problem-based learning in teacher education: Trajectories of change', *International Journal of Humanities and Social Science*, vol. 4, no. 12, pp. 17–29, viewed 02 May 2023, <https://www.ijhssnet.com/journals/Vol_4_No_12_October_2014/3.pdf>

Dillon, S, McDonnell, A, Murphy, D & White, L 2018, *Alternative methods to traditional written exam-based assessment*, viewed 11 July 2022, <https://arrow.tudublin.ie/ltcpgdprp>

Dolmans, DH, De Grave, W, Wolfhagen, EH & Van der Vleuten, CP 2005, 'Problem-based learning: Future challenges for educational practice and research', *Medical Education*, vol. 39, pp. 732–741. https://doi.org/10.1111/j.1365-2929.2005.02205.x

Dolmans, DHJM, Snellen-Balendong, H, Wolfhagen, IHAP & Van der Vleuten, CPM 1997, 'Seven principles of effective case design for a problem-based curriculum', *Medical Teacher*, vol. 19, no. 3, pp. 185–189. https://doi.org/10.3109/01421599709019379

Dos Santos, SC 2017, 'PBL-SEE: An authentic assessment model for PBL-based software engineering education', *IEEE Transactions on Education*, vol. 60, no. 2, pp. 120–126. https://doi.org/10.1109/TE.2016.2604227

Duman, B & Özçelik, C 2018, 'The effect of the creative drama-supported problem-based learning approach on the self-efficacy ability in Geometry', *Universal Journal of Educational Research*, vol. 6, no. 12, pp. 2918–2924. https://doi.org/10.13189/UJER.2018.061227

Ellingsen, P, Tonholm, T, Johansen, FR & Andersson, G 2021, 'Learning from problem-based projects in cross-disciplinary student teams', *Educational Science*, vol. 11, no. 6, a259. https://doi.org/10.3390/educsci11060259

English, MC & Kitsantas, A 2013, 'Supporting student self-regulated learning in problem- and project-based learning', *Interdisciplinary Journal of Problem-based Learning*, vol. 7, no. 2, pp. 128–150. https://doi.org/10.7771/1541-5015.1339

Ertmer, PA & Glazewski, KD 2015, 'Essentials for PBL implementation: Fostering collaboration, transforming roles, and scaffolding learning', in A Walker, H Leary, C Hmelo-Silver & PA Ertmer (eds.), *The essentials of problem-based learning: Exploring and extending the legacy of Howard S. Barrows*, Purdue University Press, West Lafayette, pp. 89–106.

Ertmer, PA & Glazewski, KD 2019, 'Scaffolding in PBL environments: Structuring and problematizing relevant task features', in M Moallem, W Hung & N Dabbagh (eds.), *The Wiley handbook of problem-based learning*, Wiley, Hoboken, pp. 321–342.

Flood, J, Heath, SB & Lapp, D 2015, *Handbook of research on teaching literacy through the communicative and visual arts, volume II: A project of the International Reading Association*, Routledge, London.

Francom, GM 2010, 'Teach me how to learn: Principles for fostering students' self-directed learning skills', *International Journal of Self-directed Learning*, vol. 7, no. 1, pp. 29–43.

Fukuzawa, S, Boyd, C & Cahn, J 2017, 'Student motivation in response to problem-based learning', *Collected Essays on Learning and Teaching*, vol. X, pp. 175–187. https://doi.org/10.22329/celt.v10i0.4748

Gadicherla, S, Kulkarni, A, Rao, C & Rao, MY 2022, 'Perception and acceptance of problem-based learning as a teaching-learning method among undergraduate medical students and faculty', *Azerbaijan Medical Journal*, vol. 62, no. 3, pp. 975–982.

Gallagher, SA, Stepien, WJ, Sher, BT & Workman, D 1995, 'Implementing problem-based learning in the science classroom', *School of Science and Mathematics*, vol. 95, no. 3, pp. 136–146. https://doi.org/10.1111/j.1949-8594.1995.tb15748.x

Gilbert, JK & Alfonso, AS 2015, 'Lifelong learning: Approaches to increasing the understanding of chemistry by everybody', in J Garcia-Martinez & E Serrano-Torregrosa (eds.), *Chemistry education: Best practices, opportunities and trends*, Wiley-VCH, Weinheim, pp. 123–148.

Goh, K 2014, 'What good teachers do to promote effective student learning in a problem-based learning environment', *Australian Journal of Educational & Developmental Psychology*, vol. 14, no. 1, pp. 159–166, viewed 02 May 2023, <https://files.eric.ed.gov/fulltext/EJ1041678.pdf>

Golightly, A 2018, 'The influence of an integrated PBL format on geography students' perceptions of their self-directedness in learning', *Journal of Geography in Higher Education*, vol. 42, no. 3, pp. 460–478. https://doi.org/10.1080/03098265.2018.1463974

Golightly, A 2021a, 'Self-and peer-assessment of pre-service geography teachers' contribution in problem-based learning activities in geography education', *International Research in Geographical and Environmental Education*, vol. 30, no. 1, pp. 75–90. https://doi.org/10.1080/10382046.2020.1744242

Golightly, A 2021b, 'Building bridges: The impact of scaffolds in PBL on the learning of South African pre-service geography teachers', *Journal of Geography in Higher Education*, vol. 47, no. 1, pp. 37–55. https://doi.org/10.1080/03098265.2021.1990227

Golightly, A & Guglielmino, LM 2015, 'Geography students' and student tutors' perceptions of their self-directedness in learning in an integrated PBL model: An exploratory study', *International Journal of Self-Directed Learning*, vol. 12, no. 2, pp. 63–81.

Golightly, A & Muniz, OA 2013, 'Are South African Geography education students ready for problem-based learning?', *Journal of Geography in Higher Education*, vol. 37, no. 3, pp. 432–455. https://doi.org10.1080/03098265.2013.794332

González, L 2019, 'The problem-based learning model', *Eighth International Conference on Educational Innovation through Technology (EITT)*, Biloxi, 27–31 October, pp. 180–183. https://doi.org/10.1109/EITT.2019.00042

Grant, MM 2011, 'Learning, beliefs, and products: Students' perspectives with project-based learning', *Interdisciplinary Journal of Problem-Based Learning*, vol. 5, pp. 37–69. https://doi.org/10.7771/1541-5015.1254

Hmelo, CE & Lin, X 2000, 'Becoming self-directed learners: Strategy development in problem-based learning', in DH Evensen & CE Hmelo (eds.), *Problem-based learning: A research perspective on learning interactions*, Lawrence Erlbaum Associates Publishers, Mahwah, pp. 227–250.

Hmelo-Silver, CE & Barrows, HS 2006, 'Goals and strategies of a problem-based learning facilitator', *The Interdisciplinary Journal of Problem-Based Learning*, vol. 1, pp. 21–39. https://doi.org/10.7771/1541-5015.1004

Hmelo-Silver, CE, Duncan, RG & Chinn, CA 2007, 'Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006)', *Educational Psychologist*, vol. 42, pp. 99–107. https://doi.org/10.1080/00461520701263368

Huang, B, Hew, KF & Lo, CK 2019, 'Investigating the effects of gamification-enhanced flipped learning on undergraduate students' behavioral and cognitive engagement', *Interactive Learning Environments*, vol. 27, no. 8, pp. 1106–1126. https://doi.org/10.1080/10494820.2018.1495653

Hung, W 2006, 'The 3C3R model: A conceptual framework for designing problems in PBL', *Interdisciplinary Journal of Problem-based Learning*, vol. 1, no. 1, pp. 55–77. https://doi.org/10.7771/1541-5015.1006

Hung, W 2019, 'Problem design in PBL', in M Moallem, W Hung & N Dabbagh (eds.), *The Wiley handbook of problem-based learning*, John Wiley & Sons, Hoboken, pp. 249–274. https://doi.org/10.1002/9781119173243.ch11

Hussin, WNTW, Harun, J & Shukor, NA 2019, 'Problem-based learning to enhance students' critical thinking skills via online tools', *Asian Social Science*, vol. 15, no. 1, pp. 14–23. https://doi.org/10.5539/ass.v15n1p14

Ibrahim, ME & Al-Shahrani, AM 2018, 'Implementing of a problem-based learning strategy in a Saudi medical school: Requisites and challenges', *International Journal of Medical Education*, vol. 9, pp. 83–85. https://doi.org/10.5116/ijme.5aae.2db8

Jonassen, DH 2000, 'Toward a design theory of problem solving', *Educational Technology Research and Development* (*ETR&D)*, vol. 48, no. 4, pp. 63–85. https://doi.org/10.1007/BF02300500

Jonassen, DH 2011, *Design problems for secondary students*, Publications, Paper 164, viewed 27 June 2022, <https://digitalcommons.usu.edu/ncete_publications/164>.

Jonassen, DH & Hung, W 2008, 'All problems are not equal: Implications for problem-based learning', *Interdisciplinary Journal of Problem-Based Learning*, vol. 2, pp. 6–28. https://doi.org/10.7771/1541-5015.1080

Kek, MYCA & Huijser, H 2011, 'The power of problem-based learning in developing critical thinking skills: Preparing students for tomorrow's digital futures in today's classrooms', *Higher Education Research & Development*, vol. 30, pp. 317–329. https://doi.org/10.1080/07294360.2010.501074

Kek, MYCA & Huijser, H 2017, *Problem-based learning into the future: Imagining an agile PBL ecology for learning*, Springer, Singapore. https://doi.org/10.1007/978-981-10-2454-2

Kiili, K 2007, 'Foundation for problem-based gaming', *British Journal of Educational Technology*, vol. 38, no. 3, pp. 394–404. https://doi.org/10.1111/j.1467-8535.2007.00704.x

Kivela, J & Kivela, RJ 2005, 'Student perceptions of an embedded problem-based learning instructional approach in a hospitality undergraduate programme', *International Journal of Hospitality Management*, vol. 24, no. 3, pp. 437–464. https://doi.org/10.1016/j.ijhm.2004.09.007

Knowles, MS 1975, *Self-directed learning: A guide for learners and teachers*, Prentice-Hall, Englewood Cliffs.

Koh, K & Chapman, O 2019, 'Problem-based learning, assessment literacy, mathematics knowledge, and competencies in teacher education', *Papers on Postsecondary Learning and Teaching*, vol. 3, pp. 74–80.

Koh, K, Delanoy, N, Bene, R, Thomas, C, Danysk, G, Hone, G, Turner, J & Chapman O 2019, 'The role of authentic assessment tasks in problem-based learning', *Papers on Postsecondary Learning and Teaching: Proceedings of the University of Calgary Conference on Learning and Teaching*, vol. 3, pp. 17–24.

Kolmos, A 2008, 'Problem-based and project-based learning: Institutional and global change', in O Skovsmose, P Valero & O Christensen (eds.), *University science and mathematics education in transition*, Springer, Boston, pp. 261–280. https://doi.org/10.1007/978-0-387-09829-6_13

Kong, L, Qin, B, Zhou, Y, Mou, S & Gao, H 2014, 'The effectiveness of problem-based learning on development of nursing students' critical thinking: A systematic review and meta-analysis', *International Journal of Nursing Studies*, vol. 51, no. 3, pp. 458–469. https://doi.org/10.1016/j.ijnurstu.2013.06.009

Lapuz, AM & Fulgencio, M 2020, 'Improving the critical thinking skills of secondary school students using problem-based learning', *International Journal of Academic Multidisciplinary Research*, vol. 4, no. 1, pp. 1–7.

Lee, Y, Mann, KV & Frank, BW 2010, 'What drives students' self-directed learning in a hybrid PBL curriculum?', *Advances in Health Sciences Education*, vol. 15, pp. 425–437. https://doi.org/10.1007/s10459-009-9210-2

Li, H 2013, 'The interpretation of problem-based learning: A case study', *Journal of Problem-Based Learning in Higher Education*, vol. 1, no. 1, pp. 176–193.

Li, J & De Luca, R 2014, 'Review of assessment feedback', *Studies in Higher Education*, vol. 39, no. 2, pp. 378–393. https://doi.org/10.1080/03075079.2012.709494

Lockspeiser, TM, O'Sullivan, P, Teherani, A & Muller, J 2008, 'Understanding the experience of being taught by peers. The value of social and cognitive congruence', *Advances in Health Sciences Education*, vol. 13, no. 3, pp. 361–372. https://doi.org/10.1007/s10459-006-9049-8

Loyens, SMM, Magda, J & Rikers, RMJP 2008, 'Self-directed in problem-based learning and its relationship with self-regulated learning', *Educational Psychology Review*, vol. 20, pp. 411–427. https://doi.org/10.1007/s10648-008-9082-7

Lu, J, Bridges, SM & Hmelo-Silver, C 2014, 'Problem-based learning', in RK Sawyer (ed.), *The Cambridge handbook of the learning sciences*, 2nd edn, Cambridge University Press, Cambridge, pp. 298–318.

MacDonald, R & Savin-Baden, M 2004, 'A briefing on assessment in problem-based learning', *LTSN Generic Centre*, vol. 13, Heslington, York.

Mansor, AN, Abdullah, NO, Wahab, JA, Rasul, MS, Nor, MYM, Nor, NM & Raof, RA 2015, 'Managing problem-based learning: Challenges and solutions for educational practice', *Asian Social Science*, vol. 11, no. 4, pp. 259–268. https://doi.org/10.5539/ass.v11n4p259

Michalewicz, Z, Falkner, N & Sooriamurthi, R 2011, 'Puzzle-based learning: An introduction to critical thinking and problem solving', *Decision Line*, vol. 42, no. 5, pp. 6–9.

Moallem, M & Igoe, E 2020, 'Problem-based learning and computer-based scaffolds in online learning', in P Isaias, DG Sampson & D Ifenthaler (eds.), *Online teaching and learning in higher education*, Spinger Nature, Cham, pp. 135–160.

Morgado, S & Leite, L 2013, 'Science and geography teachers' conceptions regarding problem-based learning related concepts', *Procedia – Social and Behavioral Sciences*, vol. 106, pp. 2343–2347. https://doi.org/10.1016/j.sbspro.2013.12.268

Mubuuke, A, Louw, A & Van Schalkwyk, S 2016, 'Utilizing students' experiences and opinions of feedback during problem-based learning tutorials to develop a facilitator feedback guide: An exploratory qualitative study', *BMC Medical Education*, vol. 16, p. 6. https://doi.org/10.1186/s12909-015-0507-y

Mulaudzi, MA 2021, 'The implementation of hybrid problem-based learning to foster senior phase technology student teachers" self-directed learning abilities', MEd thesis, Faculty of Education, North-West University.

Naji, KK, Ebead, U, Al-Ali, AK & Du, X 2020, 'Comparing models of problem and project-based learning courses and student engagement in civil engineering in Qatar', *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 16, no. 8, p. em1867. https://doi.org/10.29333/ejmste/8291

Ortiz, AM 2011, 'Fifth grade students' understanding of ratio and proportion in an engineering robotics program', *Proceedings of the 2011 ASEE Annual Conference & Exposition*, Vancouver, 26–29 July.

Preus, B 2012, 'Authentic instruction for 21st century learning: Higher-order thinking in an inclusive school', *American Secondary Education*, vol. 40, no. 3, pp. 59–79.

Pyle, A & Danniels, E 2017, 'A continuum of play-based learning: The role of the teacher in play-based pedagogy and the fear of hijacking play', *Early Education and Development*, vol. 28, no. 3, pp. 274–289. https://doi.org/10.1080/10409289.2016.1220771

Robinson, JD & Persky, AM 2020, 'Commentary: Developing self-directed learners', *American Journal of Pharmaceutical Education*, vol. 84, no. 3, pp. 292–296. https://doi.org/10.5688/ajpe847512

Salinitri, FD, Wilhelm, SM & Crabtree, BL 2015, 'Facilitating facilitators: Enhancing PBL through a structured facilitator development program', *Interdisciplinary Journal of Problem-Based Learning*, vol. 9, no. 1, pp. 37–82. https://doi.org/10.7771/1541-5015.1509

Savery, JR 2006, 'Overview of problem-based learning: Definitions and distinctions', *Interdisciplinary Journal of Problem-Based Learning*, vol. 181, pp. 9–20. https://doi.org/10.7771/1541-5015.1002

Savery, JR 2015, 'Overview of problem-based learning: Definitions and distinctions', in A Walker, H Leary, CE Hmelo-Silver & PA Ertmer (eds.), *Essential readings in problem-based learning: Exploring and extending the legacy of Howard S. Barrows*, Purdue University Press, West Lafayette, pp. 5–15.

Savery, JR 2019, 'Comparative pedagogical models of problem-based learning', in M Moallem, W Hung & N Dabbagh (eds.), *The Wiley handbook of problem-based learning*, Wiley Blackwell, Hoboken, pp. 81–104.

Savin-Baden, M 2008, *Learning spaces: Creating opportunities for knowledge-creation in academic life*, McGraw-Hill/Open University Press, Maidenhead, p. 184.

Scheer, A, Noweski, C & Meinel, C 2012, 'Transforming constructivist learning into action: Design thinking in education', *Design and Technology*, vol. 17, no. 3, pp. 8–19.

Schmidt, HG & Moust, JHC 2000, 'Factors affecting small-group tutorial learning: A review of research', in DH Evensen & CE Hmelo-Silver (eds.), *Problem-based learning: A research perspective on learning interactions*, Lawrence Erlbaum, Mahwah, pp. 19–52.

Schmidt, HG, Rotgans, JI & Yew, EH 2011, 'The process of problem-based learning: What works and why', *Medical Education*, vol. 45, no. 8, pp. 792–806. https://doi.org/10.1111/j.1365-2923.2011.04035.x

Schuwirth, LWT & Van Der Vleuten, CPM 2011, 'Programmatic assessment: From assessment of learning to assessment for learning', *Medical Teacher*, vol. 33, no. 6, pp. 478–485. https://doi.org/10.3109/0142159X.2011.565828

Sebatana, MJ & Dudu, WT 2022, 'Reality or mirage: Enhancing 21st-century skills through problem-based learning while teaching particulate nature of matter', *International Journal of Science and Mathematics Education*, vol. 20, pp. 963–980. https://doi.org/10.1007/s10763-021-10206-w

Selçuk, GS 2015, 'A problem-based learning scenario that can be used in science teacher education', *Asia-Pacific Forum on Science Learning and Teaching*, vol. 16, no. 2, pp. 1–26.

Shahbodin, F, Rosli, Z, Jusoff, K & Sui, LKM 2013, 'Hybrid problem-based learning games for effective mathematics learning', *Australian Journal of Basic and Applied Sciences*, vol. 7, no. 3, pp. 5–9.

Siarova, H, Sternadel, D & Mašidlauskaitė, R 2017, *Assessment practices for 21st century learning: Review of evidence*, NESET II report, Publications Office of the European Union, Luxembourg.

Sim, S, Azila, NMA, Lian, L, Tan, CPC & Tan, N 2006, 'A simple instrument for assessment of student performance in problem-based learning tutorials', *Annals Academy of Medicine*, vol. 35, pp. 634–641. https://doi.org/10.47102/annals-acadmedsg.V35N9p634

Simons, KD & Klein, JD 2007, 'The impact of scaffolding and student achievement levels in a problem-based learning environment', *Instructional Science*, vol. 35, no. 1, pp. 41–72. https://doi.org/10.1007/s11251-006-9002-5

Sockalingam, N 2015, 'A design model for problem-based learning', in YH Cho, IS Caleon & M Kapur (eds.), *Authentic problem-solving and learning in the 21st century*, Springer, Singapore, pp. 41–55.

Sockalingam, N & Schmidt, HG 2011, 'Characteristics of problems for problem-based learning: The students' perspective', *Interdisciplinary Journal of Problem-Based Learning*, vol. 5, no. 1, pp. 6–33. https://doi.org/10.7771/1541-5015.1135

Sridharan, B & Boud, D 2019, 'The effects of peer judgements on teamwork and self-assessment ability in collaborative group work', *Assessment & Evaluation in Higher Education*, vol. 44, no. 6, pp. 894–909. https://doi.org/10.1080/02602938.2018.1545898

Stanford University Newsletter on Teaching 2001, 'Speaking of teaching: Problem-based learning', *Quarterly by the Centre for Teaching and Learning*, vol. 11, no. 1, pp. 1–8.

Tan, OS 2005, 'Problem-based learning: The future frontiers', in K Tan, M Lee, J Mok & R Ravindran (eds.), *Problem-based learning: New directions and approaches*, Learning Academy, Temasek Centre for Problem-based Learning, Singapore, pp. 17–32.

Tandoğan, RO & Akinoğlu, O 2007, 'The effects of problem-based active learning in science education on students'' academic achievement, attitude and concept learning', *Online Submission*, vol. 3, no. 1, pp. 71–81. https://doi.org/10.12973/ejmste/75375

Torp, L & Sage, S 2002, *Problems as possibilities: Problem-based learning for K–12 education*, 2nd edn, ASCD, Alexandria.

Van den Hurk, MM, Wolfhagen, IHAP, Dolmans, DJHM & Van der Vleuten, CPM 1999, 'The impact of student-generated learning issues on individual study time and academic achievement', *Medical Education*, vol. 33, pp. 808–814. https://doi.org/10.1046/j.1365-2923.1999.00403.x

Varadarajan, S & Ladage, S 2022, 'Exploring the role of scaffolds in problem-based learning (PBL) in an undergraduate chemistry laboratory', *Chemistry Education Research Practice*, vol. 23, pp. 159–172. https://doi.org/10.1039/D1RP00180A

Walker, A & Leary, H 2009, 'A problem-based learning meta-analysis: Differences across problem types, implementation types, disciplines, and assessment levels', *Interdisciplinary Journal of Problem-Based Learning*, vol. 3, no. 1, pp. 6–28. https://doi.org/10.7771/1541-5015.1061

Walker, A & Shelton, BE 2008, 'Problem-based educational games: Connections, prescriptions, and assessment', *Journal of Interactive Learning Research*, vol. 19, no. 4, pp. 663–684.

Walker, JT & Lofton, SP 2003, 'Effect of a problem-based learning curriculum on students' perceptions of self-directed learning', *Issues in Educational Research*, vol. 13, pp. 71–100.

Wijnen, M, Loyens, SM, Smeets, G, Kroeze, MJ & Van der Molen, HT 2017, 'Students' and teachers' experiences with the implementation of problem-based learning at a University Law School', *Interdisciplinary Journal of Problem-Based Learning*, vol. 11, no. 2, p. 5. https://doi.org/10.7771/1541-5015.168

Witherspoon, EB, Schunn, CD, Higashi, RM & Baehr, EC 2016, 'Gender, interest, and prior experience shape opportunities to learn programming in robotics competitions', *International Journal STEM Education*, vol. 3, pp. 1–12. https://doi.org/10.1186/s40594-016-0052-1

Wood, DF 2008, 'Problem-based learning', *Acta Biochimica Polonica*, vol. 51, no. 2/2004, pp. XXI–XXVI, viewed 03 March 2022, <https://www.researchgate.net/publication/5395517>.

Woods, DR 2006, *Preparing for PBL*, 3rd edn, McMaster University, Hamilton.

Yarnall, L & Ostrander, J 2011, 'If you build it will they come? Supporting faculty in assessing problem-based learning', in J Davies, E de Graaff & A Kolmos (eds.), *PBL across the* *disciplines: Research into best practice, Proceedings of the 3rd International Symposium on Problem-Based Learning*, Coventry University, 28–29 November, pp. 621–633, viewed 07 September 2022, <www.ucpbl.net/digitalAssets/44/44259_13679_coventry-flyer.pdf>.

Yeung, S 2010, 'Problem-based learning for promoting student learning in high school geography', *Journal of Geography*, vol. 109, no. 5, pp. 190–200. https://doi.org/10.1080/00221341.2010.501112

Zakaria, MI, Maat, SM & Khalid, F 2019, 'A systematic review of problem-based learning in education', *Creative Education*, vol. 10, pp. 2671–2688. https://doi.org/10.4236/ce.2019.1012194

Chapter 2

Afari, E & Khine, MS 2017, 'Robotics as an educational tool: Impact of LEGO® MINDSTORMS®', *International Journal of Information and Education Technology*, vol. 7, no. 6, pp. 437–442. https://doi.org/10.18178/ijiet.2017.7.6.908

Ahlcrona, M 2012, 'The Puppet's communicative potential as a mediating tool in preschool education', *International Journal of Early Childhood*, vol. 44, pp. 171–184. https://doi.org/10.1007/s13158-012-0060-3

Aldowah, H, Al-Samarraie, H & Fauzy, WM 2019, 'Educational data mining and learning analytics for 21st century higher education: A review and synthesis', *Telematics and Informatics*, vol. 37, pp. 13–49. https://doi.org/10.1016/j.tele.2019.01.007

Ali, SS 2019, 'Problem-based learning: A learner-centered approach', *English Language Teaching*, vol. 12, no. 5, pp. 73–78. https://doi.org/10.5539/elt.v12n5p73

Alimisis, D 2013, 'Educational robotics: Open questions and new challenges', *Themes in Science and Technology Education*, vol. 6, no. 1, pp. 63–71.

Anzoategui, LGC, Pereira, MIAR & Jarrín, MDCS 2017, 'Cubetto for preschoolers: Computer programming code to code', *2017 International Symposium on Computers in Education (SIIE)*, IEEE, Leiria, Portugal, November, pp. 1–5.

Arksey, H & O'Malley, L 2005, 'Scoping studies: Towards a methodological framework', *International journal of social research methodology*, vol. 8, no. 1, pp. 19–32.

Arnott, L & Yelland, NJ 2020, 'Multimodal lifeworlds: Pedagogies for play inquiries and explorations', *Journal of Early Childhood Education Research*, vol. 9, no. 1, pp. 124–146.

Avcı, B & Şahin, F 2019, 'The effect of LEGO Mindstorm projects on problem solving skills and scientific creativity of teacher candidate' ['Öğretmen adaylarının problem çözme becerilerine ve bilimsel yaratıcılıklarına LEGO Mindstorm projelerinin etkisi'], *Journal of Human Sciences*, vol. 16, no. 1, pp. 216–230. https://doi.org/10.14687/jhs.v16i1.5658

Bandura, A, Barbaranelli, C, Caprara, GV & Pastorelli, C 2001, 'Self-efficacy beliefs as shapers of children's aspirations and career trajectories', *Child Development*, vol. 72, no. 1, pp. 187–206. https://doi.org/10.1111/1467-8624.00273

Bary, R & Rees, M 2006, 'Is (self-directed) learning the key skill for tomorrow's engineers?', *European Journal of Engineering Education*, vol. 31, no. 1, pp. 73–81. https://doi.org/10.1080/03043790500429021

Baumer, S 2013, 'Play pedagogy and playworlds', in *Encyclopedia on early childhood development*, viewed 07 July 2023, <https://www.child-encyclopedia.com/play/according-experts/play-pedagogy-and-playworlds>

Bendixen-Noe, M 2010, 'Bringing play back to the classroom: How teachers implement board and card games based on academic learning standards', *Proceedings of the European Conference on Games Based Learning*, Curran Associates, New York, pp. 13–18.

Binkley, S 2014, *Happiness as enterprise: An essay on neoliberal life*, SUNY Press, Albany.

Blaschke, LM 2012, 'Heutagogy and lifelong learning: A review of heutagogical practice and self-determined learning', *The International Review of Research in Open and Distributed Learning*, vol. 13, no. 1, pp. 56–71. https://doi.org/10.19173/irrodl.v13i1.1076

Blaschke, LM & Hase, S 2016, 'Heutagogy: A holistic framework for creating twenty-first-century self-determined learners', in *The future of ubiquitous learning*, Springer, Berlin, pp. 25–40.

Blaschke, LM & Hase, S 2019, 'Heutagogy and digital media networks', *Pacific Journal of Technology Enhanced Learning*, vol. 1, no. 1, pp. 1–14.

Bores-García, D, Hortigüela-Alcalá, D, Fernández-Rio, FJ, González-Calvo, G & Barba-Martín, R 2021, 'Research on cooperative learning in physical education: Systematic review of the last five years', *Research Quarterly for Exercise and Sport*, vol. 92, no. 1, pp. 146–155. https://doi.org/10.1080/02701367.2020.1719276

Boyle, P, Halfacree, K & Robinson, V 2014, *Exploring contemporary migration*, Routledge, London.

Brėdikytė, M 2002, 'Dialogical drama with puppets (DDP) as a method of fostering children's verbal creativity', in *The puppet – What a miracle*, Klaipėda University, Klaipeda, pp. 33–60.

Brits, S, De Beer, J & Mabotja, S 2016, 'Through the eyes of a puppet: A pedagogy of play for the incorporation of indigenous knowledge in the life and natural sciences curriculum', *Perspectives in Education*, vol. 39, no. 3, pp. 121–137.

Broussard, SC & Garrison, MB 2004, 'The relationship between classroom motivation and academic achievement in elementary-school-aged children', *Family and Consumer Sciences Research Journal*, vol. 33, no. 2, pp. 106–120. https://doi.org/10.1177/1077727X04269573

Butler, DL & Winne, PH 1995, 'Feedback and self-regulated learning: A theoretical synthesis', *Review of Educational Research*, vol. 65, pp. 245–281. https://doi.org/10.3102/00346543065003245

Candy, P, Harri-Augstein, S & Thomas, L 1985, 'Reflection and the self-organized learner: A model for learning conversations', in D Boud, R Keogh & D Walker (eds.), *Reflection: Turning experience into learning*, Kogan Page, London, pp. 100–116.

Çankaya, S, Durak, G & Yünkül, E 2017, 'Education on programming with robots: Examining learners' experiences and views', *Turkish Online Journal of Qualitative Inquiry*, vol. 8, no. 4, pp. 428–445. https://doi.org/10.17569/tojqi.343218

Chang, B 2019, 'Reflection in learning', *Online Learning*, vol. 23, no. 1, pp. 95–110. https://doi.org/10.24059/olj.v23i1.1447

Chan, S & Yuen, M 2014, 'Personal and environmental factors affecting teachers' creativity-fostering practices in Hong Kong', *Thinking Skills and Creativity*, vol. 12, pp. 69–77. https://doi.org/10.1016/J.TSC.2014.02.003

Cornelissen, JP 2017, 'Preserving theoretical divergence in management research: Why the explanatory potential of qualitative research should be harnessed rather than suppressed', *Journal of Management Studies*, vol. 54, no. 3, pp. 368–383.

Corno, L 1989, 'Self-regulated learning: A volitional analysis', in BJ Zimmerman & DH Schunk (eds.), *Self-regulated learning and academic achievement: Theory, research, and practice*, Springer-Verlag, New York, pp. 111–141.

Cullen, S, Fan, J, Van der Brugge, E & Elga, A 2018, 'Improving analytical reasoning and argument understanding: A quasi-experimental field study of argument visualization', *Science of Learning*, vol. 3, no. 1, pp. 1–6. https://doi.org/10.1038/s41539-018-0038-5

Danniels, E & Pyle, A 2018, 'Defining play-based learning', in *Encyclopedia on early childhood development*, Université de Montréal, Montréal, pp. 1–5.

Delbridge, R & Fiss, PC (eds.) 2013, 'Editors' comments: Styles of theorizing and the social organization of knowledge', *Academy of management review*, vol. 38, no. 3, pp. 325–331.

Dima, A & Tsiaras, EKA 2021, *Drama education through storytelling strategy develops learners' critical thinking skills*, Diamond Scientific Publishing, Oxford.

Dimnjašević, I 2020, 'The benefits of drama education in lower elementary school', Phd thesis, Josip Juraj Strossmayer University of Osijek, Osijek.

Dondlinger, MJ 2007, 'Educational video game design: A review of the literature', *Journal of applied educational technology*, vol. 4, no. 1, pp. 21–31.

Dron, J & Anderson, T 2014, *Teaching crowds: Learning and social media*, Athabasca University Press, Athabasca.

Evans, IM, Harvey, ST, Buckley, L & Yan, E 2009, 'Differentiating classroom climate concepts: Academic, management and emotional environments', *Kōtuitui: New Zealand Journal of Social Sciences Online*, vol. 4, no. 2, pp. 131–146. https://doi.org/10.1080/1177083X.2009.9522449

Farné, R 2005, 'Pedagogy of play', *Topoi*, vol. 24, no. 2, p. 169.

Feuerstein, R, Feuerstein, RS, Falik, L & Rand, Y 2006, *Creating and enhancing cognitive modifiability: The Feuerstein Instrumental Enrichment Program, Part I Theoretical and conceptual foundations, Part II, Practical applications of the Feuerstein Instrumental Enrichment Program*, ICELP Publications, Washington DC.

Fulmer, I 2012, 'Editor's comments: The craft of writing theory articles – Variety and similarity in AMR', *Academy of Management Review*, vol. 37, no. 3, pp. 327–331.

Garnett, F & O'Beirne, R 2013, 'Putting heutagogy into learning', in S Hase & C Kenyon (eds.), *Self-determined learning: Heutagogy in action*, Bloomsbury Academic, London, pp. 131–143.

Garrison, DR 1991, 'Critical thinking and adult education: A conceptual model for developing critical thinking in adult learners', *International Journal of Lifelong Education*, vol. 10, no. 4, pp. 287–303. https://doi.org/10.1080/0260137910100403

Garrison, DR 1993, 'A cognitive constructivist view of distance education: An analysis of teaching-learning assumptions', *Distance Education*, vol. 14, pp. 199–211. https://doi.org/10.1080/0158791930140204

Garrison, DR 1997, 'Self-directed learning: Toward a comprehensive model', *Adult Education Quarterly*, vol. 48, no. 1, pp. 18–33. https://doi.org/10.1177/074171369704800103

Gee, JP 2005, 'Learning by design: Good video games as learning machines', *E-learning and Digital Media*, vol. 2, no. 1, pp. 5–16. https://doi.org/10.2304/elea.2005.2.1.5

Gee, JP 2007, *Good video games + good learning: Collected essays on video games, learning, and literacy*, Peter Lang, Bern.

Gilson, LL & Goldberg, CB 2015, 'Editors' comment: So, what is a conceptual paper?', *Group & Organization Management*, vol. 40, no. 2, pp. 127–130. https://doi.org/10.1177/1059601115576425

Gobec, D 2012, 'Emotional-social curriculum of the trnovo model of basic learning stimulated by a puppet', *Promoting the Social Emotional Aspects of Education: A Multi-faceted Priority*, Pedagoška Fakulteta, Ljubljana, pp. 62–68

Guy, R & Byrne, B 2013, 'Neuroscience and learning: Implications for teaching practice', *Journal of Experimental Neuroscience*, vol. 7, p. 39. https://doi.org/10.4137/JEN.S10965

Hagger, MS, Gucciardi, DF, Turrell, AS & Hamilton, K 2019, 'Self-control and health-related behaviour: The role of implicit self-control, trait self-control, and lay beliefs in self-control', *British Journal of Health Psychology*, vol. 24, no. 4, pp. 764–786. https://doi.org/10.1111/bjhp.12378

Halverson, LR & Graham, CR 2019, 'Learner engagement in blended learning environments: A conceptual framework', *Online Learning*, vol. 23, no. 2, pp. 145–178. https://doi.org/10.24059/olj.v23i2.1481

Harasim, L 2017, *Learning theory and online technologies*, Routledge, London.

Hase, S & Kenyon, C 2013, *Self-determined learning: Heutagogy in action*, A&C Black, New York.

Hergenhan, BR & Olson, MH 2009, *Theories of learning (teori belajar) edisi bahasa Indonesia*, Kencana Prenada Media Group, Jakarta.

Heritage, M 2018, 'Assessment for learning as support for learner self-regulation', *The Australian Educational Researcher*, vol. 45, no. 1, pp. 51–63. https://doi.org/10.1007/s13384-018-0261-3

Hirschheim, R 2008, 'Some guidelines for the critical reviewing of conceptual papers', *Journal of the Association for Information Systems*, vol. 9, no. 8, p. 21.

Jaakkola, E 2020, 'Designing conceptual articles: Four approaches', *AMS Review*, vol. 10, no. 1–2, pp. 18–26.

Jensen, CN, Seager, TP & Cook-Davis, A 2018, 'LEGO® SERIOUS PLAY® in multidisciplinary learner teams', *International Journal of Management and Applied Research*, vol. 5, no. 4, pp. 264–280. https://doi.org/10.18646/2056.54.18-020

Johal, W 2020, 'Research trends in social robots for learning', *Current Robotics Reports*, vol. 1, no. 3, pp. 75–83. https://doi.org/10.1007/s43154-020-00008-3

Johnson, DW, Johnson, R & Holubec, E 2013, *Cooperation in the classroom*, 9th edn, Interaction Book Company, Edina.

Jonassen, D, Davidson, M, Collins, M, Campbell, J & Haag, BB 1995, 'Constructivism and computer-mediated communication in distance education', *American Journal of Distance Education*, vol. 9, no. 2, pp. 7–26. https://doi.org/10.1080/08923649509526885

Kaiafa, E, Dima, A & Tsiaras, A 2020, 'The use of drama-education techniques in cultivating the critical thinking skills of learners in primary schools', *Journal of International Scientific Publications*, vol. 18, pp. 139–148.

Kaimara, P & Deliyannis, I 2019, 'Why should I play this game? The role of motivation in smart pedagogy', in *Didactics of smart pedagogy*, Springer, Cham, pp. 113–137.

Kalelioğlu, F 2015, 'A new way of teaching programming skills to K-12 learners: Code. Org', *Computers in Human Behavior*, vol. 52, pp. 200–210. https://doi.org/10.1016/j.chb.2015.05.047

Kalelioğlu, F 2017, 'Using Facebook as a learning management system: Experiences of pre-service teachers', *Informatics in Education*, vol. 16, no. 1, pp. 83–101. https://doi.org/10.15388/infedu.2017.05

Kanfer, R & Ackerman, PL 1989, 'Motivation and cognitive abilities: An integrative/aptitude-treatment interaction approach to skill acquisition', *Journal of Applied Psychology*, vol. 74, no. 4, p. 657. https://doi.org/10.1037/0021-9010.74.4.657

Karatas, K & Arpaci, I 2021, 'The role of self-directed learning, metacognition, and 21st-century skills predicting the readiness for online learning', *Contemporary Educational Technology*, vol. 13, no. 3, p. ep300. https://doi.org/10.30935/cedtech/10786

Keogh, B & Naylor, S 2009, 'Puppets count', *Mathematics Teaching*, vol. 213, pp. 32–34.

Keogh, B, Naylor, S, Maloney, J & Simon, S 2008, 'Puppets and engagement in science: A case study', *Nordic Studies in Science Education*, vol. 4, no. 2, pp. 142–150. https://doi.org/10.5617/nordina.289

Khalaf, BK & Mohammed Zin, ZB 2018, 'Traditional and inquiry-based learning pedagogy: A systematic critical review', *International Journal of Instruction*, vol. 11, no. 4, pp. 545–564. https://doi.org/10.12973/iji.2018.11434a

Knittle, K, Heino, M, Marques, MM, Stenius, M, Beattie, M, Ehbrecht, F, Hagger, MS, Hardeman, W & Hankonen, N 2020, 'The compendium of self-enactable techniques to change and self-manage motivation and behaviour v. 1.0', *Nature Human Behaviour*, vol. 4, no. 2, pp. 215–223. https://doi.org/10.1038/s41562-019-0798-9

Knowles, MS 1975, 'Adult education: New dimensions', *Educational Leadership*, vol. 33, no. 2, pp. 85–88.

Korošec, H 2012, 'Playing with puppets in class – Teaching and learning with pleasure', in *The power of the puppet*, Filozofski fakultet u Splitu, Poljička cesta, p. 29.

Korošec, H 2013, 'Evaluating study of using puppets as a teaching medium in Slovenian schools', *Školski vjesnik: časopis za pedagogijsku teoriju i praksu*, vol. 62, no. 4, pp. 495–520.

Kövecses-Gősi, V 2018, 'Cooperative learning in VR environment', *Acta Polytechnica Hungarica*, vol. 15, no. 3, pp. 205–224. https://doi.org/10.12700/APH.15.3.2018.3.12

Kröger, T & Nupponen, AM 2019, 'Puppet as a pedagogical tool: A literature review', *International Electronic Journal of Elementary Education*, vol. 11, no. 4, pp. 393–401. https://doi.org/10.26822/iejee.2019450797

Kronreif, G, Prazak, B, Mina, S, Kornfeld, M, Meindl, M & Furst, M 2005, 'Playrob-robot-assisted playing for children with severe physical disabilities', *9th International Conference on Rehabilitation Robotics*, *ICORR 2005*, IEEE, Chicago, IL, United States of America, pp. 193–196.

LEGO progress report 2012, viewed 12 July 2022, <https://unglobalcompact.org/participation/report/cop/active/21013>

Lindqvist, G 1996, 'The aesthetics of play. A didactic study of play and culture in preschools', *Early Years*, vol. 17, no. 1, pp. 6–11. https://doi.org/10.1080/0957514960170102

Long, HB & Associates 2000, *Practice & theory in self-directed learning*, Motorola University Press, Schaumburg.

Loyens, SM, Magda, J & Rikers, RM 2008, 'Self-directed learning in problem-based learning and its relationships with self-regulated learning', *Educational Psychology Review*, vol. 20, pp. 411–427.

Luckin, R 2010, 'Learning contexts as ecologies of resources: A unifying approach to the interdisciplinary development of technology-rich learning activities', *International Journal on Advances in Life Sciences*, vol. 2, nos. 3 and 4, pp. 154–165.

MacInnis, DJ 2011, 'A framework for conceptual contributions in marketing', *Journal of Marketing*, vol. 75, no. 4, pp. 136–154.

Marti, P & Iacono, I 2011, 'Learning through play with a robot companion', in GJ Gelderblom, M Soede, L Adriaens & K Miesenberger (eds.), *Everyday technology for independence and care*, IOS Press, Amsterdam, pp. 526–533.

McGill, MM 2012, 'Learning to program with personal robots: Influences on learner motivation', *ACM Transactions on Computing Education*, vol. 12, no. 1, pp. 1–32. https://doi.org/10.1145/2133797.2133801

Mentz, E, Van der Walt, JL & Goosen, L 2008, 'The effect of incorporating cooperative learning principles in pair programming for learner teachers', *Computer Science Education*, vol. 18, no. 4, pp. 247–260. https://doi.org/10.1080/08993400802461396

Meredith, W 1993, 'Measurement invariance, factor analysis and factorial invariance', *Psychometrika*, vol. 58, pp. 525–543.

Merriam, SB & Caffarella, RS 1991, *Learning in adulthood*, Jossey-Bass, San Francisco.

Michaelis, JE & Mutlu, B 2018, 'Reading socially: Transforming the in-home reading experience with a learning-companion robot', *Science Robotics*, vol. 3, no. 21, a5999. https://doi.org/10.1126/scirobotics.aat5999

Mitchell, A 2018, 'Antimimetic rereading and defamiliarization in save the date', *DiGRA Conference*, Turin, Italy, 2018, pp. 1–17.

Miyazaki, K 2010, 'Teacher as the imaginative learner: Egan, Saitou and Bakhtin', in *Engaging imaginations and developing creativity in education*, Cambridge Scholars Publishing, Newcastle upon Tyne, pp. 33–44.

Mondada, F, Bonani, M, Riedo, F, Briod, M, Pereyre, L, Rétornaz, P & Magnenat, S 2017, 'Bringing robotics to formal education: The thymio open-source hardware robot', *IEEE Robotics & Automation Magazine*, vol. 24, no. 1, pp. 77–85. https://doi.org/10.1109/MRA.2016.2636372

Morris, TH 2020, 'Experiential learning – A systematic review and revision of Kolb's model', *Interactive Learning Environments*, vol. 28, no. 8, pp. 1064–1077. https://doi.org/10.1080/10494820.2019.1570279

Mortensen, TF 2012, *The LEGO history timeline*, The LEGO Group, Billund, p. 9.

Moust, J, Bouhuijs, P & Schmidt, H 2021, *Introduction to problem-based learning: A guide for learners*, Routledge, New York.

Munn, Z, Peters, MD, Stern, C, Tufanaru, C, McArthur, A & Aromataris, E 2018, 'Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach', *BMC Medical Research Methodology*, vol. 18, pp. 1–7. https://bmcmedresmethodol.biomedcentral.com/articles/10.1186/s12874-018-0611-x

Muongmee, S 2007, 'The role of lifelong learning and self-directed learning in educational reform in Thailand', *Educational Journal of Thailand*, vol. 1, no. 1, pp. 33–42.

Nilsson, ME 2009, 'Creative pedagogy of play – The work of Gunilla Lindqvist', *Mind, Culture, and Activity*, vol. 17, no. 1, pp. 14–22. https://doi.org/10.1080/10749030903342238

Nkopodi, N & Mosimege, M 2009, 'Incorporating the indigenous game of morabaraba in the learning of mathematics', *South African Journal of Education*, vol. 29, no. 3, pp. 377–392. https://doi.org/10.15700/saje.v29n3a273

Okoro, CO 2011, 'Metacognitive strategies: A viable tool for SDL', *Journal of Educational and Social Research*, vol. 1, no. 4, pp. 71–77.

Olson, MH & Hergenhahn, BR 2009, *Theories of learning*, Kencana, Jakarta, pp. 189–191.

Omodan, BI 2022, 'The potency of social constructivism on classroom productivity in universities', *Studies in Learning and Teaching*, vol. 3, no. 1, pp. 36–45. https://doi.org/10.46627/silet.v3i1.97

Ortiz-Colon, AM & Romo, JLM 2016, 'Teaching with *Scratch* in compulsory secondary education', *International Journal of Emerging Technologies in Learning (iJET)*, vol. 11, no. 2, pp. 67–70. https://doi.org/10.3991/ijet.v11i02.5094

Papadopoulos, I, Sgorbissa, A & Koulouglioti, C 2018, 'Caring robots are here to help', *Nurs Stand*, vol. 31, no. 51, pp. 18–20. https://doi.org/10.7748/ns.31.51.18.s22

Parkes, KA 2021, 'Self-directed learning strategies', in *The Oxford handbook of music performance*, vol. 1, Oxford University Press, Oxford, p. 106. https://doi.org/10.1093/oxfordhb/9780190056285.013.7

Pelch, M 2018, 'Gendered differences in academic emotions and their implications for learner success in STEM', *International Journal of STEM Education*, vol. 5, no. 1, pp. 1–15. https://doi.org/10.1186/s40594-018-0130-7

Peter, M 2021, 'Professional development in drama with learners with special educational needs and disabilities (SEND)', *Support for Learning*, vol. 36, no. 3, pp. 421–449. https://doi.org/10.1111/1467-9604.12371

Peters, MD, Godfrey, CM, Khalil, H, McInerney, P, Parker, D & Soares, CB 2015, 'Guidance for conducting systematic scoping reviews', *JBI Evidence Implementation*, vol. 13, no. 3, pp. 141–146.

Piaget, J 2003, 'Part I: Cognitive development in children: Piaget development and learning', *Journal of Research in Science Teaching*, vol. 2, no. 3, pp. 176–186. https://doi.org/10.1002/tea.3660020306

Pintrich, PR & De Groot, EV 1990, 'Motivational and self-regulated learning components of classroom academic performance', *Journal of Educational Psychology*, vol. 82, no. 1, pp. 33. https://doi.org/10.1037/0022-0663.82.1.33

Pitruzzella, S 2022, 'The dramatic self paradigm: Human nature from a drama therapist's perspective', in M Cao, R Hougham & S Scoble (eds.), *Imagining windmills*, Routledge, London, pp. 68–86.

Plass, JL, Homer, BD, Mayer, RE & Kinzer, CK 2020, *Theoretical foundations of game-based and playful learning*, MIT Press, Cambridge.

Prawat, RS 1992, 'Teachers' beliefs about teaching and learning: A constructivist perspective', *American Journal of Education*, vol. 100, pp. 354–395. https://doi.org/10.1086/444021

Purcell-Gates, L & Smith, M 2020, 'Applied puppetry: Communities, identities, transgressions', *Applied Theatre Research*, vol. 8, no. 1, pp. 3–11. https://doi.org/10.1386/atr_00022_2

Quigley, CF, Herro, D, Shekell, C, Cian, H & Jacques, L 2020, 'Connected learning in STEAM classrooms: Opportunities for engaging youth in science and math classrooms', *International Journal of Science and Mathematics Education*, vol. 18, no. 8, pp. 1441–1463. https://doi.org/10.1007/s10763-019-10034-z

Ramachandran, V & Lindsay, M 2006, 'Broken mirrors: A theory of autism', *Scientific American*, vol. 295, no. 5, pp. 63–69.

Rao, Z & Gibson, J 2019, 'The role of pretend play in supporting young children's emotional development', in *The SAGE handbook of developmental psychology and early childhood education*, SAGE Publications, London, pp. 63–79.

Remer, R & Tzuriel, D 2015, 'I teach better with the puppet – Use of puppet as a mediating tool in Kindergarten education – An evaluation', *American Journal of Educational Research*, vol. 3, no. 3, pp. 356–365. https://doi.org/10.12691/education-3-3-15

Resnick, LB 1991, 'Shared cognition: Thinking as social practice', in LB Resnick, JM Levine & SD Teasley (eds.), *Perspectives on socially shared cognition*, American Psychological Association, Washington, pp. 1–20.

Rivera-Pérez, S, Fernández-Rio, J & Iglesias Gallego, D 2021, 'Effects of an 8-week cooperative learning intervention on physical education learners' task and self-approach goals, and emotional intelligence', *International Journal of Environmental Research and Public Health*, vol. 18, no. 1, p. 61. https://doi.org/10.3390/ijerph18010061

Ruhl, KL, Hughes, CA & Schloss, PJ 1987, `Using the pause procedure to enhance lecture recall', *Teacher Education and Special Education*, vol. 10, pp. 14–18.

Ryan, RM & Deci, EL 2002, 'Overview of self-determination theory: An organismic dialectical perspective', in *Handbook of self-determination research*, vol. 2, University of Rochester Press, New York, pp. 3–33.

Saido, GM, Siraj, S, Nordin, ABB & Al_Amedy, OS 2018, 'Higher-order thinking skills among secondary school learners in science learning', *MOJES: Malaysian Online Journal of Educational Sciences*, vol. 3, no. 3, pp. 13–20.

Saks, K & Leijen, Ä 2014, 'Distinguishing self-directed and self-regulated learning and measuring them in the e-learning context', *Procedia-Social and Behavioral Sciences*, vol. 112, pp. 190–198.

Sandi-Urena, S, Cooper, M & Stevens, R 2012, 'Effect of cooperative problem-based laboratory instruction on metacognition and problem-solving skills', *Journal of Chemical Education*, vol. 89, pp. 700–706. https://doi.org/10.1021/ed1011844

Seibert, SA 2021, 'Problem-based learning: A strategy to foster Generation Z's critical thinking and perseverance', *Teaching and Learning in Nursing*, vol. 16, no. 1, pp. 85–88. https://doi.org/10.1016/j.teln.2020.09.002

Shelley, B, Ooi, CS & Brown, N 2019, 'Playful learning? An extreme comparison of the Children's University in Malaysia and in Australia', *Journal of Applied Learning & Teaching*, vol. 2, no. 1, pp. 16–23. https://doi.org/10.37074/jalt.2019.2.1.3

Sherratt, D & Peter, M 2002, *Developing play and drama in children with autistic spectrum disorders*, David Fulton Publishers, London.

Short, E, Swift-Spong, K, Greczek, J, Ramachandran, A, Litoiu, A, Grigore, EC, Feil-Seifer, D, Shuster, S, Lee, JJ, Huang, S, Levonisova, S, Litz, S, Li, J, Ragusa, G, Spruijt-Metz, D, Matariand, M & Scassellati, B 2014, 'How to train your DragonBot: Socially assistive robots for teaching children about nutrition through play', *The 23rd IEEE International Symposium on Robot and Human Interactive Communication*, IEEE, Edingburgh, United Kingdom, pp. 924–929.

Stork, MG 2020, 'Supporting twenty-first century competencies using robots and digital storytelling', *Journal of Formative Design in Learning*, vol. 4, no. 1, pp. 43–50. https://doi.org/10.1007/s41686-019-00039-w

Tanaka, F & Matsuzoe, S 2012, 'Children teach a care-receiving robot to promote their learning: Field experiments in a classroom for vocabulary learning', *Journal of Human-Robot Interaction*, vol. 1, no. 1, pp. 78–95. https://doi.org/10.5898/JHRI.1.1.Tanaka

Thomson, CK 1992, 'Learner-centered tasks in the foreign language classroom', *Foreign Language Annals*, vol. 25, no. 6, pp. 523–531. https://doi.org/10.1111/j.1944-9720.1992.tb01137.x

Toh, W 2018, *A multimodal approach to video games and the player experience*, Routledge, New York.

Toh, W & Kirschner, D 2020, 'Self-directed learning in video games, affordances and pedagogical implications for teaching and learning', *Computers & Education*, vol. 154, p. 103912. https://doi.org/10.1016/j.compedu.2020.103912

Tran, VD 2019, 'Does cooperative learning increase learners' motivation in learning?', *International Journal of Higher Education*, vol. 8, no. 5, pp. 12–20. https://doi.org/10.5430/ijhe.v8n5p12

Turgut, S & Gülşen Turgut, İ 2018, *The effects of cooperative learning on mathematics achievement in turkey a meta-analysis study*, Gate Association for Teaching and Education, Zurich.

Tzuriel, D & Remer, R 2018, ‘Mediation with a puppet: The effects on teachers’ mediated learning strategies with children in special education and regular kindergartens’, *Learning and Instruction*, vol. 58, pp. 295–304. https://doi.org/10.1016/j.learninstruc.2018.08.001

Verma, V, Baron, T, Bansal, A & Amresh, A 2019, ‘Emerging practices in game-based assessment’, in *Game-based assessment revisited*, Springer, Cham, pp. 327–346.

Viirret, TL 2018, ‘Shared experiencing, shared understandings: Intersubjectivity as a key phenomenon in drama education’, *Applied Theatre Research*, vol. 6, no. 2, pp. 155–166. https://doi.org/10.1386/atr.6.2.155_1

Vogt, F, Hauser, B, Stebler, R, Rechsteiner, K & Urech, C 2018, ‘Learning through play pedagogy and learning outcomes in early childhood mathematics’, *European Early Childhood Education Research Journal*, vol. 26, no. 4, pp. 589–603. https://doi.org/10.1080/1350293X.2018.1487160

Vygotsky, LS 1967, ‘Play and its role in the mental development of the child’, *Soviet Psychology*, vol. 5, no. 3, pp. 6–18. https://doi.org/10.2753/RPO1061-040505036

Vygotsky, LS 1987, *The collected works of LS Vygotsky: Problems of the theory and history of psychology*, vol. 3, Springer Science & Business Media, Berlin.

Warburton, N & Volet, S 2012, ‘Enhancing self-directed learning through a content quiz group learning assignment’, *Active Learning in Higher Education*, vol. 14, no. 1, pp. 9–22. https://doi.org/10.1177/1469787412467126

Watkins, KE & Marsick, VJ 1992, ‘Towards a theory of informal and incidental learning in organizations’, *International Journal of Lifelong Education*, vol. 11, no. 4, pp. 287–300. https://doi.org/10.1080/0260137920110403

Wells, G 1999, *Dialogic inquiry: Towards a socio-cultural practice and theory of education*, Cambridge University Press, Cambridge.

Whiteland, SR 2016, ‘Exploring aging attitudes through a puppet making research study’, *International Journal of Education & the Arts*, vol. 17, no. 3, p. 3.

Whitton, N 2018, ‘Playful learning: Tools, techniques, and tactics’, *Research in Learning Technology*, vol. 26, p. 2035. https://doi.org/10.25304/rlt.v26.2035

Williamson, SN 2007, ‘Development of a self-rating scale of self-directed learning’, *Nursing Research*, vol. 14, pp. 66–83. https://doi.org/10.7748/nr2007.01.14.2.66.c6022

Williamson, G 2015, *Self-regulated learning: An overview of metacognition, motivation and behaviour*, Royal College of Nursing, London.

Wood, EA 2014, ‘Free choice and free play in early childhood education: Troubling the discourse’, *International Journal of Early Years Education*, vol. 22, no. 1, pp. 4–18. https://doi.org/10.1080/09669760.2013.830562

Zap, N & Code, J 2009, ‘Self-regulated learning in video game environments’, in R Ferdig (ed.), *Handbook of research on effective electronic gaming in education*, IGI Global, New York, pp. 738–756.

Zeng, C 2019, ‘An overview of current trends in drama education in the People’s Republic of China’, *Research in Drama Education: The Journal of Applied Theatre and Performance*, vol. 24, no. 4, pp. 472–477. https://doi.org/10.1080/13569783.2019.1643710

Zheng, C & Tan, B 2019, *Theory-driven integrated formative feedback design for online adult learners*, Association for Information Systems eLibrary, Atlanta.

Zhong, B, Liu, X, Xia, L & Sun, W 2022, ‘A proposed taxonomy of teaching models in STEM education: Robotics as an example’, *SAGE Open*, vol. 12, no. 2, p. 21582440221099525. https://doi.org/10.1177/21582440221099525

Zimmerman, BJ & Schunk, DH 2001, *Self-regulated learning and academic achievement: Theoretical perspectives*, Routledge, New York.

Zosh, JN, Hopkins, EJ, Jensen, H, Liu, C, Neale, D, Hirsh-Pasek, K, Solis, SL & Whitebread, D 2017, *Learning through play: A review of the evidence*, LEGO Fonden, Billund.

Chapter 3

Banksy 2022, *Banksy*, viewed 12 September 2022, <https://banksy.co.uk/>

Bargh, JA & Schul, Y 1980, 'On the cognitive benefits of teaching', *Journal of Educational Psychology*, vol 72, no. 5, pp. 593–604. https://doi.org/10.1037/0022-0663.72.5.593

Bawa, P 2019, 'Using Kahoot to inspire', *Journal of Educational Technology Systems*, vol. 47, no. 3, pp. 373–390. https://doi.org/10.1177/0047239518804173

Benware, CA & Deci, EL 1984, 'Quality of learning with an active versus passive motivational set', *American Educational Research Journal*, vol. 21, no. 4, pp. 755–765. https://doi.org/10.3102/00028312021004755

Brom, C, Šisler, V, Slussareff, M, Selmbacherová, T & Hlávka, Z 2016, 'You like it, you learn it: Affectivity and learning in competitive social role-play gaming', *International Journal of Computer-Supported Collaborative Learning*, vol. 11, no. 3, pp. 313–348. https://doi.org/10.1007/s11412-016-9237-3

Buur, JL, Schmidt, PL & Barr, MC 2013, 'Using educational games to engage students in veterinary basic sciences', *Journal of Veterinary Medical Education*, vol. 40, no. 3, pp. 278–281. https://doi.org/10.3138/jvme.0113-014R

Detwiler, S, Jacobson, TE & O'Brien, K 2018, 'BreakoutEDU: Helping students break out of their comfort zones', *College & Research Libraries News*, vol. 79, no. 2, pp. 62–66. https://doi.org/10.5860/crln.79.2.62

Dweck, CS 2008, *Mindset: The new psychology of success*, Ballantine Books, New York.

Edwards, S 2013, 'Digital play in the early years: A contextual response to the problem of integrating technologies and play-based pedagogies in the early childhood curriculum', *European Early Childhood Education Research Journal*, vol. 21, no. 2, pp. 199–212. https://doi.org/10.1080/1350293X.2013.789190

Flavell, JH 1979, 'Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry', *American Psychologist*, vol. 34, no. 10, pp. 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Freire, P 2000, *Pedagogy of the oppressed*, 30th anniversary edn, Continuum, New York.

Garrison, DR 1997, 'Self-directed learning: Towards a comprehensive model', *Adult Education Quarterly*, vol. 48, no. 1, pp. 18–33. https://doi.org/10.1177/074171369704800103

Gibbons, M 2002, *The self-directed learning handbook: Challenging adolescent students to excel*, 1st edn, Jossey-Bass, San Francisco.

Ignacio, J & Chen, H-C 2020, 'The use of web-based classroom gaming to facilitate cognitive integration in undergraduate nursing students: A mixed methods study', *Nurse Education in Practice*, vol. 46, p. 102820. https://doi.org/10.1016/j.nepr.2020.102820

Immordino-Yang, MH & Damasio, AR 2016, 'We feel, therefore we learn: The relevance of affective and social neuroscience to education', in *Emotions, learning, and the brain: Exploring the educational implications of affective neuroscience*, W. W. Norton & Company, New York, pp. 27–42.

Immordino-Yang, MH & Fischer, KW 2016, 'Neuroscience bases of learning', in *Emotions, learning, and the brain: Exploring the educational implications of affective neuroscience*, W. W. Norton & Company, New York, pp. 79–92.

Institute for Experiential Learning 2021, *What Is experiential learning?*, Institute for Experiential Learning, viewed 14 September 2023, <https://experientiallearninginstitute.org/>

Jacobson, TE, Mackey, T, O'Keeffe, E & Forte, M 2018, *Metaliteracy goals and learning objectives, metaliteracy*, viewed 12 September 2022, <https://metaliteracy.org/learning-objectives/2018-metaliteracy-goals-and-learning-objectives/>.

Jacobson, TE & Mackey, TP 2013, 'Proposing a metaliteracy model to redefine information literacy', *Communications in Information Literacy*, vol. 7, no. 2, pp. 84–91. https://doi.org/10.15760/comminfolit.2013.7.2.138

Jacobson, TE, Mackey, TP & Olivier, J 2021, 'Aligning metaliteracy with self-directed learning to expand assessment opportunities', in E Mentz & A Lubbe (eds.), *Learning through assessment: An approach towards self-directed learning*, NWU Self-Directed Learning Series, vol. 7, AOSIS Books, Cape Town, pp. 71–97. https://doi.org/10.4102/aosis.2021.BK280.04

Johnson, DW & Johnson, RT 1990, 'Using cooperative learning in math', in N Davidson (ed.), *Cooperative learning in mathematics*, Addison-Wesley, Menlo Park, pp. 103–125.

Kebritchi, M, Hirumi, A & Bai, H 2010, 'The effects of modern mathematics computer games on mathematics achievement and class motivation', *Computers & Education*, vol. 55, no. 2, pp. 427–443. https://doi.org/10.1016/j.compedu.2010.02.007

Keller, JM 1987, 'Development and use of the ARCS model of instructional design', *Journal of Instructional Development*, vol. 10, no. 3, pp. 2–10.

Keller, JM 2008, 'An integrative theory of motivation, volition, and performance', *Technology, Instruction, Cognition and Learning*, vol. 6, pp. 79–104.

Knowles, MS 1975, *Self-directed learning: A guide for learners and teachers*, Association Press, New York.

Kress, G 2011, '"Partnerships in research": Multimodality and ethnography', *Qualitative Research*, vol. 11, no. 3, pp. 239–260. https://doi.org/10.1177/1468794111399836

Kress, GR 2010, *Multimodality: A social semiotic approach to contemporary communication*, Routledge, London.

Li, J 2022, *Jiabao Li*, viewed 12 September 2022, <https://www.jiabaoli.org/>

Li, L 2022, 'Developing a pedagogy of play: Toddlers' conceptual learning in a PlayWorld', *Early Years*, vol. 42, no. 3, pp. 278–292. https://doi.org/10.1080/09575146.2020.1739002

Lindqvist, G 2001, 'The relationship between play and dance', *Research in Dance Education*, vol. 2, no. 1, pp. 41–52. https://doi.org/10.1080/14647890120058302

Linkr Education 2022, *Linkr Education*, viewed 12 September 2022, <https://www.lovelearning.org/>

Mackey, T 2021, 'Translating a blended Cyprus residency study in the digital arts to online', *All About Mentoring Autumn*, vol. 2021, no. 55, pp. 37–42.

Mackey, TP 2019, 'Empowering metaliterate learners for the post-truth world', in TP Mackey & TE Jacobson (eds.), *Metaliterate learning for the post truth world*, ALA Neal-Schuman, Chicago, IL, pp. 1–32.

Mackey, TP & Aird, SM 2022, 'Integrating metaliteracy into the design of a collaborative online international learning (COIL) course in digital storytelling', *Open Praxis*, vol. 13, no. 4, pp. 397–403. https://doi.org/10.55982/openpraxis.13.4.442

Mackey, TP & Jacobson, TE 2011, 'Reframing information literacy as a metaliteracy', *College & Research Libraries*, vol. 72, no. 1, pp. 62–78. https://doi.org/10.5860/crl-76r1

Mackey, TP & Jacobson, TE 2014, *Metaliteracy: Reinventing information to empower learners*, Neal-Schuman, Chicago, IL.

Mackey, TP & Jacobson, TE 2022, *Metaliteracy in a connected world: Developing learners as producers*, ALA Neal-Schuman, Chicago, IL.

Mackey, TP, Jacobson, TE & O'Brien, KL 2020, *Integrated metaliterate learner figure*, viewed 12 September 2022, <https://metaliteracy.org/ml-in-practice/integrated-metaliterate-learner-figure/>

Metaliteracy Learning Collaborative 2014, *Metaliteracy badging system*, viewed 12 September 2022, <https://sites.google.com/view/metaliteracy>

MoMA 2022, *Cindy Sherman American, born 1954*, Museum of Modern Art, viewed 12 September 2022, <https://www.moma.org/artists/5392>

Nilsson, ME 2009, 'Creative pedagogy of play – The work of Gunilla Lindqvist', *Mind, Culture, and Activity*, vol. 17, no. 1, pp. 14–22. https://doi.org/10.1080/10749030903342238

O'Brien, KL 2018, 'Failing better: Scaffolding learning with the Metaliteracy Badging System', in K O'Brien & TE Jacobson (eds.), *Teaching with digital badges: Best practices for libraries, innovations in information literacy*, Rowman & Littlefield, Lanham, pp. 183–197.

Olivier, J (ed.) 2020, *Self-directed multimodal learning in higher education*, in NWU Self-Directed Learning Series, vol. 5, AOSIS Books, Cape Town. https://doi.org/10.4102/aosis.2020.BK210

Palaiologou, I 2016, 'Teachers' dispositions towards the role of digital devices in play-based pedagogy in early childhood education', *Early Years*, vol. 36, no. 3, pp. 305–321. https://doi.org/10.1080/09575146.2016.1174816

Pitt, MB, Borman-Shoap, EC & Eppich, WJ 2015, 'Twelve tips for maximizing the effectiveness of game-based learning', *Medical Teacher*, vol. 37, no. 11, pp. 1013–1017. https://doi.org/10.3109/0142159X.2015.1020289

Rogers, S & Evans, J 2007, 'Rethinking role-play in the reception class', *Educational Research*, vol. 49, no. 2, pp. 153–167. https://doi.org/10.1080/00131880701369677

Schwenk, TL & Whitman, S 1984, *Residents as teachers*, University of Utah School of Medicine, Salt Lake City.

Stentoft, D 2017, 'From saying to doing interdisciplinary learning: Is problem-based learning the answer?', *Active Learning in Higher Education*, vol. 18, no. 1, pp. 51–61. https://doi.org/10.1177/1469787417693510

Thatcher, DC 1990, 'Promoting learning through games and simulations', *Simulation & Gaming*, vol. 21, no. 3, pp. 262–273. https://doi.org/10.1177/1046878190213005

The Training Thinking 2015, *The four stage learning cycle by David Kolb*, The Training Thinking, viewed 14 June 2023, <https://thetrainingthinking.com/en/the-four-stage-learning-cycle-by-david-kolb/>

Vogt, F, Hauser, B, Stebler, R, Rechsteiner, K & Urech, C 2018, 'Learning through play – Pedagogy and learning outcomes in early childhood mathematics', *European Early Childhood Education Research Journal*, vol. 26, no. 4, pp. 589–603. https://doi.org/10.1080/1350293X.2018.1487160

Vygotsky, LS & Cole, M 1978, *Mind in society: The development of higher psychological processes*, Harvard University Press, Cambridge.

Whitman, N 1988, *Peer teaching: To teach is to learn twice*, Association for the Study of Higher Education, College Station.

Wingert, DA & Molitor, T 2015, *'But, we didn't mean to teach porn': The power of play in teaching and learning*, Tomorrow's Professor Postings, s.l.

Woo, J-C 2014, 'Digital game-based learning supports student motivation, cognitive success, and performance outcomes', *Journal of Educational Technology & Society*, vol. 17, no. 3, a2910397.

Wood, D, Bruner, JS & Ross, G 1976, 'The role of tutoring in problem-solving', *Journal of Child Psychology and Psychiatry*, vol. 17, no. 2, pp. 89–100. https://doi.org/10.1111/j.1469-7610.1976.tb00381.x

Wood, D, Bruner, JS & Ross, G 2019, *Telling your digital story*, viewed 12 September 2022, <https://youtu.be/PIH9NvDwrP0>.

Chapter 4

Allen, KA, Boyle, C, Lachlan, F & Craig, H 2020, 'How multi-systemic social skills training can pave the way for inclusive practices for students with autism spectrum disorders in mainstream schools', in C Boyle, S Mavropoulou, J Anderson & A Page (eds.), *Inclusive education: Global issues & controversies*, Brill, Leiden, pp. 525–550.

Allen, KA, Kern, M, McInerney, D, Rozec, C & Slavich, G 2021, 'Belonging: A review of conceptual issues, an integrative framework, and directions for future research', *Australian Journal of Psychology*, vol. 73, no. 1, pp. 87–102. https://doi.org/10.1080/00049530.2021.1883409

Allen, KA, Kern, ML, Vella-Brodrick, D, Hattie, J & Waters, L 2018, 'What schools need to know about fostering school belonging: A meta-analysis', *Educational Psychology Review*, vol. 30, no. 1, pp. 1–34. https://doi.org/10.1007/s10648-016-9389-8

Allen, KA, Vella-Brodrick, D & Waters, L 2016, 'Fostering school belonging in secondary schools using a socio-ecological framework', *The Educational and Developmental Psychologist*, vol. 33, no. 1, pp. 97–121. https://doi.org/10.1017/edp.2016.5

Ananiadou, K & Claro, M 2009, *21st century skills and competences for new millennium learners in OECD countries*, OECD Education Working Papers, no. 41, Organisation for Economic Co-operation and Development, Paris. https://doi.org/10.1787/218525261154

Andreopoulou, P & Moustakas, L 2019, 'Playful learning and skills improvement', *Open Journal for Educational Research*, vol. 3, no. 1, pp. 25–38. https://doi.org/10.32591/coas.ojer.0301.03025a

Arslan, G 2018, 'Exploring the association between school belonging and emotional health among adolescents', *International Journal of Educational Psychology*, vol. 7, no. 1, pp. 21–41. https://doi.org/10.17583/ijep.2018.3117

Arslan, G 2021, 'School bullying and youth internalising and externalising behaviors: Do school belonging and school achievement matter?', *International Journal of Mental Health and Addiction*, vol. 29, no. 3, pp. 289–306. https://doi.org/10.1007/s11469-021-00526-x

Arslan, G, Allen, K & Ryan, T 2020, 'Exploring the impacts of school belonging on youth wellbeing and mental health: A longitudinal study', *Child Indicators Research*, vol. 13, no. 5, pp. 1619–1635. https://doi.org/10.1007/s12187-020-09721-z

Arslan, G & Duru, E 2017, 'Initial development and validation of the school belongingness scale', *Child Indicators Research*, vol. 10, no. 4, pp. 1043–1058. https://doi.org/10.1007/s12187-016-9418-7

Baker, ST, Le Courtois, S & Eberhart, J 2023, 'Making space for children's agency with playful learning', *International Journal of Early Years Education*, vol. 31, no. 2, pp. 372–384. https://doi.org/10.1080/09669760.2021.1997726

Bandura, A, Ross, D & Ross, S 1963, 'Vicarious reinforcement and imitative learning', *Journal of Abnormal and Social Psychology*, vol. 67, no. 6, pp. 601–607. https://doi.org/10.1037/h0045550

Barrett, T 2005, 'Who said learning couldn't be enjoyable, playful and fun? The voice of PBL students', in E Poikela & S Poikela (eds.), *PBL in context: Bridging work and education*, Tampere University Press, Tampere, pp. 159–175.

Bennett, J, Lubben, F & Hogarth, S 2007, 'Bringing science to life: A synthesis of the research evidence on the effects of context-based and STS approaches to science teaching', *Science Education*, vol. 91, no. 3, pp. 347–370. https://doi.org/10.1002/sce.20186

Clarke, V, Braun, V & Hayfield, N 2015, 'Thematic analysis', in JA Smith (ed.), *Qualitative psychology: A practical guide to research methods*, 5th edn., SAGE Publications, London.

De Jong, O 2006, 'Making chemistry meaningful: Conditions for successful context-based teaching', *Educacion Quimica*, vol. 17, pp. 215–221. https://doi.org/10.22201/fq.18708404e.2006.4e.66010

Department of Basic Education 2020, *E3 learning model: Pedagogical paradigms*, viewed 04 May 2023, <https://www.ecubed-dbe.org/wp-content/uploads/2020/07/E3-Learning-Model-pedagogical-content_display.01.20.pdf>

Dorgu, TE 2015, 'Different teaching methods: A panacea for effective curriculum implementation in the classroom', *International Journal of Secondary Education*, vol. 3, no. 6, pp. 77–87. https://doi.org/10.11648/j.ijsedu.s.2015030601.13

Du Toit-Brits, C 2022, 'Exploring the importance of a sense of belonging for a sense of ownership in learning', *South African Journal of Higher Education*, vol. 36, no. 5, pp. 58–76. https://doi.org/10.20853/36-5-4345

Du Toit-Brits, C, Blignaut, H & Mzuza, MK 2021, 'The promotion of self-directed learning through the African philosophy of *ubuntu*', in E Mentz, J Olivier & D Laubscher (eds.), *Self-directed learning: An imperative for education in a complex society*, NWU Self-Directed

Learning Series, vol. 6, AOSIS Books, Cape Town, pp. 1–24. https://doi.org/10.4102/aosis.2021.BK279.01

Freire, P 1993, *Pedagogy of the oppressed: 30th Anniversary edition*, Continuum, New York.

Garrison, DR 1997, 'Self-directed learning: Toward a comprehensive model', *Adult Education Quarterly*, vol. 48, no. 1, pp. 18–33. https://doi.org/10.1177/074171369704800103

Gelman, SA 2009, 'Learning from others: Children's construction of concepts', *Annual Review of Psychology*, vol. 60, pp. 115–140. https://doi.org/10.1146/annurev.psych.59.103006.093659

Harris, PL 2012, *Trusting what you're told: How children learn from others*, The Belknap Press of Harvard University Press, Cambridge.

Hendarwati, E, Nurlaela, L & Bachri, BS 2021, 'The collaborative problem-based learning model innovation', *Journal of Educational and Social Research*, vol. 11, no. 4, p. 97. http://doi.org/10.36941/jesr-2021-0080

Henricks, TS 2014, 'Play as self-realisation: Toward a general theory of play', *American Journal of Play*, vol. 6, no. 2, pp. 190–213, viewed 04 May 2023, <https://files.eric.ed.gov/fulltext/EJ1023798.pdf>.

Hmelo-Silver, CE 2004, 'Problem-based learning: What and how do students learn?', *Educational Psychology Review*, vol. 16, no. 3, pp. 235–266. https://doi.org/10.1023/B%3AEDPR.0000034022.16470.F3

Hurst, B, Wallace, RR & Nixon, SB 2013, 'The impact of social interaction on student learning', *Reading Horizons: A Journal of Literacy and Language Arts*, vol. 52, no. 4, pp. 375–398.

Husbye, NE, Buchholz, B, Coggin, LS, Powell, CW & Wohlwend, KE 2012, 'Critical lessons and playful literacies: Digital media in PK-2 classrooms', *Language Arts*, vol. 90, no. 2, pp. 82–92.

Joorst, JP 2021, 'Why should an ethics of care matter in education?', *Transformation in Higher Education*, vol. 6, p. a127. https://doi.org/10.4102/the.v6i0.127

Kangas, J, Harju-Luukkainen, H, Brotherus, A, Gearon, LF & Kuusisto, A 2022, 'Outlining play and playful learning in Finland and Brazil: A content analysis of early childhood education policy documents', *Contemporary Issues in Early Childhood*, vol. 23, no. 2, pp. 153–165. https://doi.org/10.1177/1463949120966104

Kangas, M, Siklander, P, Randolph, J & Ruokamo, H 2017, 'Teachers' engagement and students' satisfaction with a playful learning environment', *Teaching and Teacher Education*, vol. 63, pp. 274–284. https://doi.org/10.1016/j.tate.2016.12.018

Kapur, R 2018, *The significance of social constructivism in education*, viewed 20 September 2022, <https://www.researchgate.net/publication/323825342_The_Significance_of_Social_Constructivism_in_Education>

Karatas, K & Arpaci, I 2021, 'The role of self-directed learning, metacognition, and 21st-century skills predicting the readiness for online learning', *Contemporary Educational Technology*, vol. 13, no. 3, a300. https://doi.org/10.30935/cedtech/10786

Klein, EJ 2008, 'Learning, unlearning, and relearning: Lessons from one school's approach to creating and sustaining learning communities', *Teacher Education Quarterly*, vol. 35, no. 1, pp. 79–97. https://www.jstor.org/stable/23479032

Knowles, MS 1975, *Self-directed learning: A guide for students and educators*, Cambridge Adult Education, Englewood Cliffs.

Kumashiro, KK 2000, 'Toward a theory of anti-oppressive education', *Review of Educational Research*, vol. 70, no. 1, pp. 25–53. https://doi.org/10.3102/00346543070001025

Leather, M, Harper, N & Obee, P 2021, 'A pedagogy of play: Reasons to be playful in postsecondary education', *Journal of Experiential Education*, vol. 44, no. 3, pp. 208–226. https://doi.org/10.1177/1053825920959684

LEGO® Foundation 2017, *What we mean by: Learning through play*, viewed 20 September 2022, <https://cms.learningthroughplay.com/media/vd5fiurk/what-we-mean-by-learning-through-play.pdf>

Leite, L 2017, 'Introduction. Why should contextualised teaching be a matter for educational concern?', in L Leite, LGP Dourado, AS Afonso & SF Morgado (eds.), *Contextualising teaching to improve learning: The case of science and geography*, Nova Science Publishers, New York.

Lester, L & Cross, D 2015, 'The relationship between school climate and mental and emotional well-being over the transition from primary to secondary school', *Psychology of Well-being*, vol. 5, no. 1, pp. 1–15. https://doi.org/10.1186/s13612-015-0037-8

Lizcano-Dallos, AR, Vargas-Daza, M & Barbosa-Chacón, JW 2019, 'Collaborative learning and technologies in higher education. Characteristics, advantages and disadvantages for its implementation', *EDULEARN19 Proceedings: 11th International Conference on Education and New Learning Technologies*, Palma, Spain, 01–03 July, pp. 7713–7719.

Loeng, S 2020, 'Self-directed learning: A core concept in adult education', *Education Research International*, vol. 2020, a3816132. https://doi.org/10.1155/2020/3816132

Lombardi, MM 2007, *Authentic learning for the 21st century: An overview*, Educause Learning Initiative Paper 1, p. 12, Educause Learning Initiative, viewed 10 July 2023, <https://library.educause.edu/-/media/files/library/2007/1/eli3009-pdf>

Lynneth Solis, S, Ertel, KE, Mardell, B, Fan, S, LeVangie, S, Maurer, G & Scarpate, M 2021, *Empowering, meaningful, and joyful: Playful learning in six schools in the United States*, President and Fellows of Harvard College, Cambridge.

Maestas, R, Vaquera, GS & Zehr, LM 2017, 'Factors impacting sense of belonging at a hispanic-serving institution', *Journal of Hispanic Higher Education*, vol. 6, no. 3, pp. 237–256. https://doi.org/10.1177/1538192707302801

Mardell, B, Lynneth Solis, S & Bray, O 2019, 'The state of play in school: Defining and promoting playful learning in formal education settings', *International Journal of Play*, vol. 8, no. 3, pp. 232–236. https://doi.org/10.1080/21594937.2019.1684157

Martinez-Callaghan, J & Gill-Lacruz, M 2017, 'Developing identity, sense of belonging and social networks among Japanese immigrants in Scotland and Spain', *Asian and Pacific Migration Journal*, vol. 26, no. 2, pp. 241–261. https://doi.org/10.1177/0117196817706034

Maslow, AH 1962, *Towards a psychology of need*, Van Nostrand, Princeton.

Maslow, AH 1970, *Motivation and personality*, Harper & Row, New York.

Maslow, AH 1987, *Motivation and personality*, 3rd edn., Harper & Row, New York.

McKinley, J 2015, 'Critical argument and writer identity: Social constructivism as a theoretical framework for EFL academic writing', *Critical Inquiry in Language Studies*, vol. 12, no. 3, pp. 184–207. https://doi.org/10.1080/15427587.2015.1060558

Moon-Seo, SK & Munsell, SE 2022, 'Play as a medium for children's learning from parents' perspectives', *Educational Research: Theory and Practice*, vol. 33, no. 2, pp. 23–31.

Myburgh, S & Tammaro, M 2013, 'Pedagogies and teaching methods', in S Myburgh & AM Tamarro (eds.), *Exploring education for digital librarians: Meaning, modes and models*, pp. 211–230, Chandos Publishing, Oxford.

Nilson, LB 2016, *Teaching at its best: A research-based resource for college instructors*, John Wiley & Sons, New York.

OECD 2019, *Programme for International Student Assessment (PISA) 2018 results (Volume III): What school life means for students' lives*, Programme for International Student Assessment (PISA), OECD Publishing, Paris. https://doi.org/10.1787/acd78851-en

Ormrod, JE 2017, *Human learning*, 7th edn., Pearson, Essex.

Overton, T 2007, 'Context and problem-based learning', in *New directions in the teaching of physical sciences*, vol. 3, pp. 7–12. https://doi.org/10.11120/ndir.2007.00030007

Papert, S 1996, *The connected family: Bridging the digital generation gap*, Longstreet Press, Atlanta.

Poikela, E & Poikela, S 2005, *PBL in context: Bridging work and education*, University of Tampere, Tampere.

Reynolds, AJ, Ou, SR, Mondi, CF & Hayakawa, M 2017, ‘Processes of early childhood interventions to adult well-being’, *Child Development*, vol. 88, no. 2, pp. 378–387. https://doi.org/10.1111/cdev.12733

Reznitskaya, A, Anderson, RC & Kuo, LJ 2007, ‘Teaching and learning argumentation’, *Elementary School Journal*, vol. 107, pp. 449–472. https://doi.org/10.1086/518623

Ryan, RM & Deci, EL 2000a, ‘Intrinsic and extrinsic motivations: Classic definitions and new directions’, *Contemporary Educational Psychology*, vol. 25, no. 1, pp. 54–67. https://doi.org/10.1006/ceps.1999.1020

Ryan, RM & Deci, EL 2000b, ‘Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being’, *American Psychologist*, vol. 55, no. 1, pp. 68–78. https://doi.org/10.1037/0003-066x.55.1.68

Ryan, RM, Deci, EL, Vansteenkiste, M & Soenens, B 2021, ‘Building a science of motivated persons: Self-determination theory’s empirical approach to human experience and the regulation of behavior’, *Motivation Science*, vol. 7, no. 2, pp. 97–110. https://doi.org/10.1037/mot0000194

Savery, JR 2015, ‘Overview of problem-based learning: Definitions and distinctions’, in A Walker, H Leary & C Hmelo-Silver (eds.), *Essential readings in problem-based learning: Exploring and extending the legacy of Howard S. Barrows*, Purdue University Press, West Lafayette, pp. 5–15.

Schunk, DH 2016, *Learning theories: An educational perspective*, 7th edn., Pearson, Boston.

Seligman, M 2011, *Flourish: A new understanding of happiness and well-being: The practical guide to using positive psychology to make you happier and healthier*, John Murray Press, Hachette.

Seligman, M 2018, ‘PERMA and the building blocks of well-being’, *The Journal of Positive Psychology*, vol. 13, no. 4, pp. 333–335. https://doi.org/10.1080/17439760.2018.1437466

Shah, RK 2019, ‘Effective constructivist teaching–learning in the classroom’, *Shanlax International Journal of Education*, vol. 7, no. 4, pp. 1–13. https://doi.org/10.34293/education.v7i4.600

Snyder, CR 2002, ‘Hope theory: Rainbows in the mind’, *Psychological Inquiry*, vol. 13, no. 4, pp. 249–275. https://doi.org/10.1207/S15327965PLI1304_01

StatsSA 2020, *General household survey*, viewed 19 September 2022, <http://www.statssa.gov.za/publications/P0318/P03182020.pdf>

Tome, JMS 2021, ‘Learn to unlearn for transformative learning: An epistemological look’, *Philosophy Study*, vol. 11, no. 2, pp. 107–115. https://doi.org/10.17265/2159-5313/2021.02.004

University of Birmingham 2022, *Why work in groups?*, viewed 17 September 2022, <https://www.birmingham.ac.uk/schools/metallurgy-materials/about/cases/group-work/why.aspx>

Vygotsky, LS & Cole, M 1978, *Mind in society: The development of higher psychological processes*, Harvard University Press, Cambridge.

Vygotsky, LS 2012, *Thought and language*, MIT Press, Cambridge.

Whitton, N 2018, ‘Playful learning: Tools, techniques, and tactics’, *Research in Learning Technology*, vol. 26, a2035. https://doi.org/10.25304/rlt.v26.2035

Wood, E 2009, ‘Developing a pedagogy of play’, in A Anning, J Cullen & M Fleer (eds.), *Early childhood education: Society and culture*, 2nd edn., SAGE Publications, London, pp. 27–38.

Wood, E 2010, ‘Developing integrated pedagogical approaches to play and learning’, in P Broadhead, J Howard & E Wood (eds.), *Play and learning in the early years: From research to practice*, SAGE Publications, London, pp. 9–26.

Woolfolk, A 2016, *Educational psychology*, 13th edn., Pearson, Essex.

Chapter 5

Brennan, K & Resnick, M 2012, 'New frameworks for studying and assessing the development of computational thinking', *Proceedings of the 2012 Annual Meeting of the American Educational Research Association*, Vancouver, Canada, 13–17 April, p. 25.

Butler, D & Leahy, M 2021, 'Developing preservice teachers' understanding of computational thinking: A constructionist approach', *British Journal of Educational Technology*, vol. 52, pp. 1060–1077. https://doi.org/10.1111/bjet.13090

Czerkawski, BC & Lyman, EW 2015, 'Exploring issues about computational thinking in higher education', *TechTrends*, vol. 59, pp. 57–65. https://doi.org/10.1007/s11528-015-0840-3

Dhakulkar, A & Olivier, J 2021, 'Exploring microworlds as supporting environments for self-directed multimodal learning', in E Mentz, D Laubsher & J Olivier (eds.), *Self-directed learning: An imperative for education in a complex society*, NWU Self-Directed Learning Series, vol. 6, AOSIS Books, Cape Town, pp. 71–106. https://doi.org/10.4102/aosis.2021.BK279.04

Fagerlund, J, Häkkinen, P, Vesisenaho, M & Viiri, J 2020, 'Assessing 4th Grade students' computational thinking through *Scratch* programming projects', *Informatics in Education*, vol. 19, pp. 611–640. https://doi.org/10.15388/infedu.2020.27

Grover, S & Pea, R 2018, 'Computational thinking: A competency whose time has come', in S Sentance, S Carsten & E Barendsen (eds.), *Computer science education: Perspectives on teaching and learning in school*, Bloomsbury, London, pp. 19–38.

Guglielmino, LM 2013, 'The case for promoting self-directed learning in formal educational institutions', *SA-eDUC Journal*, vol. 10, pp. 1–18.

Hadad, S, Shamir-Inbal, T, Blau, I & Leykin, E 2021, 'Professional development of code and robotics teachers through small private online course (SPOC): Teacher centrality and pedagogical strategies for developing computational thinking of students', *Journal of Educational Computing Research*, vol. 59, pp. 763–791. https://doi.org/10.1177/0735633120973432

Hava, K & Ünlü, ZK 2021, 'Investigation of the relationship between middle school students' computational thinking skills and their STEM career interest and attitudes toward inquiry', *Journal of Science Education and Technology*, vol. 30, pp. 484–495. https://doi.org/10.1007/s10956-020-09892-y

Hsu, T-C, Chang, S-C & Hung, Y-T 2018, 'How to learn and how to teach computational thinking: Suggestions based on a review of the literature', *Computers & Education*, vol. 126, pp. 296–310. https://doi.org/10.1016/j.compedu.2018.07.004

Johnson, DW & Johnson, RT 2018, 'Cooperative learning: The foundation for active learning', in SM Brito (ed.), *Active learning beyond the future*, IntechOpen, s.l. https://doi.org/10.5772/intechopen.81086

Kelle, U, Kühberger, C & Bernhard, R 2019, 'How to use mixed-methods and triangulation designs: An introduction to history education research', *History Education Research Journal*, vol. 16, pp. 5–23. https://doi.org/10.18546/HERJ.16.1.02

Korkmaz, Ö, Çakir, R & Özden, MY 2017, 'A validity and reliability study of the computational thinking scales (CTS)', *Computers in Human Behavior*, vol. 72, pp. 558–569. https://doi.org/10.1016/j.chb.2017.01.005

Pala, FK & Mıhcı Türker, P 2021, 'The effects of different programming trainings on the computational thinking skills', *Interactive Learning Environments*, vol. 29, pp. 1090–1100. https://doi.org/10.1080/10494820.2019.1635495

Papert, S 1980, *Mindstorms, children, computers, and powerful ideas*, Basic Books, New York.

Relkin, E, De Ruiter, LE & Bers, MU 2021, 'Learning to code and the acquisition of computational thinking by young children', *Computers & Education*, vol. 169, pp. 2–15. https://doi.org/10.1016/j.compedu.2021.104222

Saldaña, J 2016, *The coding manual for qualitative researchers*, SAGE Publications, London.

Schoenfeld, AH 2016, 'Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics (Reprint)', *Journal of Education*, vol. 196, pp. 1–38. https://doi.org/10.1177/002205741619600202

Scratch n.d., Version 3.12.0, software, MIT Media Lab, Cambridge, Massachusetts.

Shahin, M, Gonsalvez, C, Whittle, J, Chen, C, Li, L & Xia, X 2022, 'How secondary school girls perceive computational thinking practices through collaborative programming with the *micro:bit*', *Journal of Systems and Software*, vol. 183, a111107. https://doi.org/10.1016/j.jss.2021.111107

Threekunprapa, A & Yasri, P 2020, 'Patterns of computational thinking development while solving unplugged coding activities coupled with the 3S approach for self-directed learning', *European Journal of Educational Research*, vol. 9, pp. 1025–1045. https://doi.org/10.12973/eu-jer.9.3.1025

Tsarava, K, Moeller, K & Ninaus, M 2018, 'Training computational thinking through board games: The case of crabs & turtles', *International Journal of Serious Games*, vol. 5, pp. 25–44. https://doi.org/10.17083/ijsg.v5i2.248

Turchi, T, Fogli, D & Malizia, A 2019, 'Fostering computational thinking through collaborative game-based learning', *Multimedia Tools and Applications*, vol. 78, pp. 13649–13673. https://doi.org/10.1007/s11042-019-7229-9

Umutlu, D 2021, 'An exploratory study of pre-service teachers' computational thinking and programming skills', *Journal of Research on Technology in Education*, vol. 54, no. 5, pp. 754–768. https://doi.org/10.1080/15391523.2021.1922105

Wing, JM 2006, 'Computational thinking', *Communications of the ACM*, vol. 49, pp. 33–35. https://doi.org/10.1145/1118178.1118215

Yildiz Durak, H 2020, 'The effects of using different tools in programming teaching of secondary school students on engagement, computational thinking and reflective thinking skills for problem solving', *Technology, Knowledge and Learning*, vol. 25, pp. 179–195. https://doi.org/10.1007/s10758-018-9391-y

Chapter 6

Adihou, A 2011, 'Enseignement-apprentissage des mathématiques et souffrance à l'école [Mathematics teaching-learning and suffering at school]', *Les Collectifs Du Cirp*, vol. 2, no. 1, pp. 90–102, viewed 22 February 2022, <https://www.usherbrooke.ca/creas/fileadmin/sites/creas/documents/Publications/Enseignement-apprentissage_Adihou_2011.pdf>

Balacheff, N 1994, 'La transposition informatique. Note sur un nouveau problème pour la didactique [Computer transposition. Note on a new problem for didactics]', *Vingt Ans de Didactique Des Mathématiques En France*, vol. 2, pp. 132–138.

Botty, HMRH, Shahrill, M, Jaidin, JH, Li, HC & Chong, MSF 2016, 'The implementation of problem-based learning (PBL) in a year 9 mathematics classroom: A study in Brunei Darussalam', *International Research in Education*, vol. 4, no. 2, pp. 34–47. https://doi.org/10.5296/ire.v4i2.9466

Brown, Q, Mongan, W, Kusic, D, Garbarine, E, Fromm, E & Fontecchio, A 2008, 'Computer aided instruction as a vehicle for problem solving: *Scratch* programming environment in the middle years classroom', vol. 22, no. 6.1, p. 1, viewed 23 February 2022, <https://strategy.asee.org/computer-aided-instruction-as-a-vehicle-for-problem-solving-scratch-boards-in-the-middle-years-classroom>

Bruillard, E 1997, *Les machines à enseigner*, Hermès, Paris.

Calao, LA, Moreno-León, J, Corrêa, HE & Robles, G 2015, 'Developing mathematical thinking with *Scratch*: An experiment with 6th-Grade students', in G Conole, T Klobučar, C Rensing, J Konert & E Lavoué (eds.), *Design for teaching and learning in a networked world*, Springer International Publishing, Cham, pp. 17–27. https://doi.org/10.1007/978-3-319-24258-3_2

Chevallard, Y 1986, 'La Transposition didactique: du savoir savant au savoir enseigné [Didactic transposition: From learned knowledge to taught knowledge]', *Revue Française de Pédagogie*, vol. 76, no. 1, pp. 89–91.

Ching-San, L & Ming-Horng, L 2012, 'Using computer programming to enhance science learning for 5th graders in Taipei', *2012 International Symposium on Computer, Consumer* *and Control*, Institute of Electrical and Electronics Engineers, Piscataway, pp. 146–148. https://doi.org/10.1109/IS3C.2012.45

Çukurbaşı, B & Kıyıcı, M 2017, 'An investigation of the effects of problem-based learning activities supported via flipped-classroom and LEGO®-LOGO practices on the success and motivation of high school students', *International Online Journal of Educational Sciences*, vol. 9, no. 1, pp. 191–206. https://doi.org/10.15345/iojes.2017.01.013

Dagiene, V, Jevsikova, T, Schulte, C, Sentance, S & Thota, N 2013, 'A comparison of current trends within computer science teaching in school in Germany and the UK', *Informatics in Schools: Local Proceedings of the 6th International Conference ISSEP 2013*, Selected Papers, Oldenburg, 26 February–02 March, p. 63.

DeBlois, L 2016, 'Penser l'enseignement de la resolution de problèmes mathématiques par la programmation informatique: quels enjeux?', *CIRTA (Communauté Pour l'Innovation et La Recherche Sur Les Technologies Dans l'enseignement/Apprentissage)*, viewed 23 February 2022, <https://www.cirta.org/index.php/50-banque-de-textes-actes-colloque-2016/233-penser-l-enseignement-de-la-resolution-de-problèmes-mathématiques-par-la-programmation-informatique-quels-enjeux>

Denning, PJ 2009, 'The profession of IT beyond computational thinking', *Communications of the ACM*, vol. 52, no. 6, pp. 28–30. https://doi.org/10.1145/1516046.1516054

Dhakulkar, A & Olivier, J 2021, 'Exploring microworlds as supporting environments for self-directed multimodal learning', in E Mentz, D Laubscher & J Olivier (eds.), *Self-directed learning: An imperative for education in a complex society*, NWU Self-Directed Learning Series, vol. 6, AOSIS Books, Cape Town, pp. 71–106. https://doi.org/10.4102/aosis.2021.BK279.04

Dijkstra, EW 1970, *Notes on structured programme*, viewed 27 September 2022, <https://www.cs.utexas.edu/users/EWD/ewd02xx/EWD249.PDF>

Dowker, A, Cheriton, O, Horton, R & Mark, W 2019, 'Relationships between attitudes and performance in young children's mathematics', *Educational Studies in Mathematics*, vol. 100, no. 3, pp. 211–230. https://doi.org/10.1007/s10649-019-9880-5

Garrison, DR 1997, 'Self-directed learning: Toward a comprehensive model', *Adult Education Quarterly*, vol. 48, no. 1, pp. 18–33. https://doi.org/10.1177/074171369704800103

Gobert, D 1992, 'Une expérience en LOGO et géométrie à l'école élémentaire [An experiment in LOGO and geometry in elementary school]', *Bulletin de l'EPI (Enseignement Public et Informatique)*, vol. 66, pp. 115–128, viewed 28 September 2022, <https://edutice.archives-ouvertes.fr/edutice-00001265>

Guieu, C 2009, 'Utiliser un langage de programmation au collège [Use a programming language in college]', *MathémaTICE*, vol. 16, viewed 28 September 2022, <http://revue.sesamath.net/spip.php?article226>

Hsu, TC, Chang, SC & Hung, YT 2018, 'How to learn and how to teach computational thinking: Suggestions based on a review of the literature', *Computers & Education*, vol. 126, pp. 296–310. https://doi.org/10.1016/j.compedu.2018.07.004

Juarez Eugenio, MDR & Aguilar, M 2018, 'El método Singapur, propuesta para mejorar el aprendizaje de las Matemáticas en Primaria [The Singapore method, a proposal to improve the learning of Mathematics in Primary]', *Números*, vol. 98, no. 12, pp. 75–86.

Kalelioğlu, F & Gülbahar, Y 2014, 'The effects of teaching programming via *Scratch* on problem solving skills: A discussion from learners' perspective', *Informatics in Education*, vol. 13, no. 1, pp. 33–50. https://doi.org/10.15388/infedu.2014.03

Knowles, MS 1975, *Self-directed learning: A guide for learners and teachers*, Follett Publishing Company, Chicago.

Lai, A-F & Yang, S-M 2011, 'The learning effect of visualized programming learning on 6th graders' problem solving and logical reasoning abilities', *2011 International Conference on Electrical and Control Engineering (ICECE)*, Institute of Electrical and Electronics Engineers, Piscataway, NJ, United States of America, 16–18 September, pp. 6940–6944. https://doi.org/10.1109/ICECENG.2011.6056908

Lewis, CM & Shah, N 2012, 'Building upon and enriching Grade four mathematics standards with programming curriculum', *The 43rd ACM Technical Symposium on Computer Science Education*, Association for Computing Machinery, New York, pp. 57–62. https://doi.org/10.1145/2157136.2157156

LOGO Foundation 2015, *LOGO history*, viewed 23 February 2022, <https://el.media.mit.edu/logo-foundation/what_is_logo/history.html>

Lunga, P, Esterhuizen, S & Koen, M 2022, 'Play-based pedagogy: An approach to advance young children's holistic development', *South African Journal of Childhood Education*, vol. 12, no. 1, p. 12. https://doi.org/10.4102/sajce.v12i1.1133

Mendelsohn, P 1985, 'The child and programming activities', *Grand N*, vol. 35, pp. 47–60.

Miller, AR & Saenz, LP 2021, 'Exploring relationships between playspaces, pedagogy, and preschoolers' play-based science and engineering practices', *Journal of Childhood, Education & Society*, vol. 2, no. 3, pp. 314–337. https://doi.org/10.37291/2717638X.202123121

Minsky, M & Papert, SA 1972, *Artificial intelligence progress report*, viewed 11 July 2023, <http://hdl.handle.net/1721.1/6087>

Mitchelmore, M & White, P 2007, 'Editorial: Abstraction in mathematics learning', *Mathematics Education Research Journal*, vol. 19, pp. 1–9. https://doi.org/10.1007/BF03217452

Modeste, S 2012, *Enseigner l'algorithme pour quoi? Quelles nouvelles questions pour les mathématiques? Quels apports pour l'apprentissage de la preuve?* Université de Grenoble, viewed 23 February 2022, <https://tel.archives-ouvertes.fr/tel-00783294/>

Moreno-León, J, Robles, G & Román-González, M 2016, 'Examining the relationship between socialization and improved software development skills in the *Scratch* code learning environment', *JUCS – Journal of Universal Computer Science*, vol. 22, no. 12, pp. 1533–1557. https://doi.org/10.3217/jucs-022-12-1533

Nijimbere, C 2014, 'Apprendre l'informatique par la programmation des robots: cas de Nao [Learning computer science by programming robots: Case of Nao]', *Sciences et Technologies de l'Information et de La Communication Pour l'Éducation et La Formation*, vol. 21, no. 1, pp. 63–109. https://doi.org/10.3406/stice.2014.1091

Organization for Economic Co-operation and Development (OECD) 2016a, *Equations and inequalities: Making mathematics accessible to all, PISA*, OECD Publishing, Paris. https://doi.org/10.1787/9789264258495-en

Organization for Economic Co-operation and Development (OECD) 2016b, *PISA 2015 results (volume I): Excellence and equity in education, PISA*, OECD Publishing, Paris. https://doi.org/10.1787/9789264266490-en

Olivier, J 2019, 'Towards a multiliteracies framework in support of self-directed learning through open educational resources', in E Mentz, J de Beer & R Bailey (eds.), *Self-directed learning for the 21st century: Implications for higher education*, NWU Self-Directed Learning Series, vol. 1, AOSIS Books, Cape Town, pp. 167–201. https://doi.org/10.4102/aosis.2019.BK134.06

Ouahbi, I, Kaddari, F, Darhmaoui, H & Elachqar, A 2017, 'L'intégration des serious games dans les cours d'introduction de l'algorithmique et de la programmation [Integration of serious games in teaching an introductory course on algorithmic and programming]', *Frantice.Net*, vol. 14, no. 1, pp. 55–72. http://frantice.net/index.php?id=1465

Ouellette, J-M 2013, *Analyse de la motivation pour les mathématiques d'élèves du secondaire participant à une activité de programmation informatique*, Mémoire, Université du Québec à Trois-Rivières, Trois-Rivières.

Papert, S 1981, *Jaillissement de l'esprit: ordinateurs et apprentissage*, viewed 23 February 2022, <https://eduq.info/xmlui/handle/11515/13235>

Popat, S & Starkey, L 2019, 'Learning to code or coding to learn? A systematic review', *Computers & Education*, vol. 128, pp. 365–376. https://doi.org/10.1016/j.compedu.2018.10.005

Pyle, A & Danniels, E 2017, 'A continuum of play-based learning: The role of the teacher in play-based pedagogy and the fear of hijacking play', *Early Education and Development*, vol. 28, no. 3, pp. 274–289. https://doi.org/10.1080/10409289.2016.1220771

Resnick, M 2013, 'Learn to code, code to learn: How programming prepares kids for more than math', *EdSurge*, vol. 54, viewed 23 February 2022, <https://www.edsurge.com/news/2013-05-08-learn-to-code-code-to-learn>

Resnick, M, Martin, F, Sargent, R & Silverman, B 1996, 'Programmable bricks: Toys to think with', *IBM Systems Journal*, vol. 35, no. 3.4, pp. 443–452. https://doi.org/10.1147/sj.353.0443

Richard, PR 2004, 'L'inférence figurale: un pas de raisonnement discursivo-graphique [Figurative inference: A step in discursivo-graphic reasoning]', *Educational Studies in Mathematics*, vol. 57, no. 2, pp. 229–263. https://doi.org/10.1023/B:EDUC.0000049272.75852.c4

Servant-Miklos, VF 2019, 'Problem-solving skills versus knowledge acquisition: The historical dispute that split problem-based learning into two camps', *Advances in Health Sciences Education*, vol. 24, no. 3, pp. 619–635. https://doi.org/10.1007/s10459-018-9835-0

Shier, H 1991, 'Exploring logo in children's play: A playworker's perspective', *Early Child Development and Care*, vol. 69, no. 1, pp. 91–97. https://doi.org/10.1080/0300443910690109

Silvern, SB 1988, 'Creativity through play with LOGO', *Childhood Education*, vol. 64, no. 4, pp. 220–224. https://doi.org/10.1080/00094056.1988.10521539

Stolee, KT & Fristoe, T 2011, 'Expressing computer science concepts through Kodu game lab', *The 42nd ACM Technical Symposium on Computer Science Education*, Association for Computing Machinery, New York, pp. 99–104. https://doi.org/10.1145/1953163.1953197

Tchounikine, P 2017, 'Initier les élèves à la pensée informatique et à la programmation avec *Scratch*', *Laboratoire d'informatique de Grenoble*, viewed 24 February 2022, <https://lig-membres.imag.fr/tchounikine/PenseeInformatiqueEcole.pdf>

Van Bakel, S & Lescanne, P 2008, 'Computation with classical sequents', *Mathematical Structures in Computer Science*, vol. 18, no. 3, pp. 555–609. https://doi.org/10.1017/S0960129508006762

Wilson, A, Hainey, T & Connolly, TM 2013, 'Using *Scratch* with primary school children: An evaluation of games constructed to gauge understanding of programming concepts', *International Journal of Game-Based Learning*, vol. 3, no. 1, pp. 93–109. https://doi.org/10.4018/ijgbl.2013010107

Winarso, W 2018, 'Authentic assessment for academic performance; study on the attitudes, skills, and knowledge of Grade 8 mathematics students', *Malikussaleh Journal of Mathematics Learning*, vol. 1, no. 1, pp. 1–8. https://doi.org/10.2139/ssrn.3159666

Wing, JM 2006, 'Computational thinking', *Communications of the ACM*, vol. 49, no. 3, pp. 33–35. https://doi.org/10.1145/1118178.1118215

Wood, DF 2003, 'Problem-based learning', *BMJ*, vol. 326, no. 7384, pp. 328–330. https://doi.org/10.1136/bmj.326.7384.328

Yildiz Durak, H 2020, 'The effects of using different tools in programming teaching of secondary school students on engagement, computational thinking and reflective-thinking skills for problem solving', *Technology, Knowledge and Learning*, vol. 25, no. 1, pp. 179–195. https://doi.org/10.1007/s10758-018-9391-y

Zavala, LA, Gallardo, SCH & García-Ruíz, MÁ 2013, 'Designing interactive activities within *Scratch* 2.0 for improving abilities to identify numerical sequences', *Proceedings of the 12th International Conference on Interaction Design and Children*, Association for Computing Machinery, New York, United States of America, June, pp. 423–426. https://doi.org/10.1145/2485760.2485831

Chapter 7

Adu-Gyamfi, K, Bossé, MJ & Lynch-Davis, K 2019, 'Three types of mathematical representational translations: Comparing empirical and theoretical results', *School Science and Mathematics*, vol. 119, no. 7, pp. 396–404. https://doi.org/10.1111/ssm.12360

Arcavi, A 2003, 'The role of visual representations in the learning of mathematics', *Educational Studies in Mathematics*, vol. 52, no. 3, pp. 215–241. https://doi.org/10.1023/A:1024312321077

Arcavi, A 2004, ‘Solving linear equations: Why, how and when?’, *For the Learning of Mathematics*, vol. 24, no. 3, pp. 25–28.

Bartolini, MG & Martignone, F 2020, ‘Manipulatives in mathematics education’, in S Lerman (ed.), *Encyclopedia of mathematics education*, Springer, Cham, pp. 487–494.

Beemer, LR, Ajibewa, TA, DellaVecchia, G & Hasson, RE 2019, ‘A pilot intervention using gamification to enhance student participation in classroom activity breaks’, *International Journal of Environmental Research and Public Health*, vol. 16, no. 21, a4082. https://doi.org/10.3390/ijerph16214082

Behl, A, Sheorey, P, Pal, A, Veetil, AKV & Singh, SR 2020, ‘Gamification in e-commerce: A comprehensive review of literature’, *Journal of Electronic Commerce in Organizations*, vol. 18, no. 2, pp. 1–16. https://doi.org/10.4018/JECO.2020040101

Bosch, C, Mentz, E & Goede, R 2019, ‘Self-directed learning: A conceptual overview’, in E Mentz, J de Beer & R Bailey (eds.), *Self-directed learning for the 21st century: Implications for higher education*, NWU Self-Directed Learning Series, vol. 1, AOSIS Books, Cape Town, pp. 1–36. https://doi.org/10.4102/aosis.2019.BK134.01

Buckley, P & Doyle, E 2016, ‘Gamification and student motivation’, *Interactive Learning Environments*, vol. 24, no. 6, pp. 1162–1175. https://doi.org/10.1080/10494820.2014.964263

Campillo-Ferrer, J-M, Miralles-Martínez, P & Sánchez-Ibáñez, R 2020, ‘Gamification in higher education: Impact on student motivation and the acquisition of social and civic key competencies’, *Sustainability*, vol. 12, p. 4822. https://doi.org/10.3390/su12124822

Cañadas, MC, Molina, M & Del Rio, A 2018, ‘Meanings given to algebraic symbolism in problem-posing’, *Educational Studies in Mathematics*, vol. 98, no. 1, pp. 19–37. https://doi.org/10.1007/s10649-017-9797-9

Casey, S, Lesseig, K, Monson, D & Krupa, EE 2018, ‘Examining pre-service secondary mathematics teachers’ responses to student work to solve linear equations’, *Mathematics Teacher Education and Development*, vol. 20, no. 1, pp. 132–153.

Castañeda-Vázquez, C, Espejo-Garcés, T, Zurita-Ortega, F & Fernández-Revelles, AB 2019, ‘La formación de los futuros docentes a través de la gamificación, tic y evaluación continua [The training of future teachers through gamification, ICT and continuous evaluation]’, *SPORT TK-Revista EuroAmericana de Ciencias Del Deporte*, vol. 8, no. 2, pp. 55–63. https://doi.org/10.6018/sportk.391751

Chen, AH 2018, *How to use OER games in the college classroom*, viewed 26 August 2022, <https://iro.uiowa.edu/discovery/fulldisplay/alma9983557450002771/01IOWA_INST:ResearchRepository>

Clement, J 1982, ‘Algebra word problem solutions: Thought processes underlying a common misconception’, *Journal for Research in Mathematics Education*, vol. 13, no. 1, pp. 16–30. https://doi.org/10.5951/jresematheduc.13.1.0016

Cohen, L, Manion, L & Morrison, K 2018, *Research methods in education*, Routledge, London.

Cress, U, Rosé, C, Wise, AF & Oshima, J (eds.) 2021, *International handbook of computer-supported collaborative learning*, Springer, New York.

Creswell, JW & Plano Clark, VL 2018, *Designing and conducting mixed methods research*, 3rd edn., SAGE Publications, California.

Deci, EL & Ryan, RM 2016, ‘Optimizing students’ motivation in the era of testing and pressure: A self-determination theory perspective’, in WC Liu, JCK Wang & RM Ryan (eds.), *Building autonomous learners*, Springer, Singapore, pp. 9–29.

De-Marcos, L, Garcia-Cabot, A & Garcia-Lopez, E 2017, ‘Towards the social gamification of e-learning: A practical experiment’, *International Journal of Engineering Education*, vol. 33, no. 1, pp. 66–73.

Deterding, S, Khaled, R, Nacke, L & Dixon, D 2011, ‘Gamification: Toward a definition’, *Proceedings of the Chi 2011 Gamification Workshop*, Vancouver, Canada, 07–12 May, pp. 1–15.

Dhakulkar, A & Nagarjuna, G 2018, 'Preparing for open educational pedagogy', *Open Education Global Conference*, Mumbai, India, n.d., pp. 24–26.

Dhakulkar, A & Olivier, J 2021, 'Exploring microworlds as supporting environments for self-directed multimodal learning', in E Mentz, D Laubscher & J Olivier (eds.), *Self-directed learning: An imperative for education in a complex society*, NWU Self-Directed Learning Series, vol. 6, AOSIS Books, Cape Town, pp. 71–106. https://doi.org/10.4102/aosis.2021.BK279.04

Dhakulkar, A, Shaikh, R & Nagarjuna, G 2017, 'Zone of proximal development in the era of connected computers', in S Ladage & S Narvekar (eds.), *Proceedings of epiSTEME 7 — International Conference to Review Research on Science, Technology and Mathematics Education*, Cinnamon Teal, Margao, pp. 214–221.

Dias, J 2017, 'Teaching operations research to undergraduate management students: The role of gamification', *The International Journal of Management Education*, vol. 15, no. 1, pp. 98–111. https://doi.org/10.1016/j.ijme.2017.01.002

Díez, JC, Bañeres, D & Serra, M 2017, 'Experiencia de gamificación en Secundaria en el Aprendizaje de Sistemas Digitales [Gamification experience in Secondary School in the Learning of Digital Systems]', *EKS*, vol. 18, pp. 85–105. https://doi.org/10.1016/j.ijme.2017.01.002

Dix, A 2008, 'Externalisation – How writing changes thinking', *Interfaces*, vol. 76, pp. 18–19.

Elkjær, M & Jankvist, UT 2021, 'Designing tasks for a dynamic online environment: Applying research into students' difficulties with linear equations', *Mathematics*, vol. 9, no. 5, a557. https://doi.org/10.3390/math9050557

Faiella, F & Ricciardi, M 2015, 'Gamification and learning: A review of issues and research', *Journal of E-Learning and Knowledge Society*, vol. 11, p. 3, viewed 07 August 2022, <https://www.learntechlib.org/P/151920/>

Fernández-Rio, J, De las Heras, E, González, T, Trillo, V & Palomares, J 2020, 'Gamification and physical education: Viability and preliminary views from students and teachers', *Physical Education and Sport Pedagogy*, vol. 25, no. 5, pp. 509–524. https://doi.org/10.1080/17408989.2020.1743253

Fischer, C, Malycha, CP & Schafmann, E 2019, 'The influence of intrinsic motivation and synergistic extrinsic motivators on creativity and innovation', *Frontiers in Psychology*, vol. 10, a137. https://doi.org/10.3389/fpsyg.2019.00137

Francom, GM 2010, 'Teach me how to learn: Principles for fostering students' self-directed learning skills', *International Journal of Self-Directed Learning*, vol. 7, no. 1, pp. 29–44.

Friberg, J 2008, 'A remarkable collection of Babylonian mathematical texts', *Notices of the American Mathematical Society*, vol. 55, no. 9, pp. 1076–1086.

Garcia-Cabot, A, Garcia-Lopez, E, Caro-Alvaro, S, Gutierrez-Martinez, JM & De-Marcos, L 2020, 'Measuring the effects on learning performance and engagement with a gamified social platform in an MSc program', *Computer Applications in Engineering Education*, vol. 28, no. 1, pp. 207–223. https://doi.org/10.1002/cae.22186

García-Holgado, A, García-Peñalvo, FJ, De la Higuera, C, Teixeira, A, Ehlers, UD, Bruton, J, Nascimbeni, F, Padilla Zea, N & Burgos, D 2020, 'Promoting open education through gamification in higher education: The OpenGame project', *Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality*, New York, United States of America, October, pp. 399–404. https://doi.org/10.1145/3434780.3436688

Gardner, M 1981, *Mathematical circus*, Penguin Books, London.

Gardner, M 1986, *Entertaining mathematical puzzles*, Dover Publications, New York.

Gatti, L, Ulrich, M & Seele, P 2019, 'Education for sustainable development through business simulation games: An exploratory study of sustainability gamification and its effects on students' learning outcomes', *Journal of Cleaner Production*, vol. 207, pp. 667–678. https://doi.org/10.1016/j.jclepro.2018.09.130

Goldin, GA 2020, 'Mathematical representations', in S Lerman (ed.), *Encyclopedia of mathematics education*, Springer, Cham, pp. 566–571. https://doi.org/10.1007/978-3-030-15789-0_103

Hall, RD 2002, 'An analysis of errors made in the solution of simple linear equations', *Philosophy of Mathematics Education Journal*, vol. 15, no. 1, pp. 1–67.

Hewitt, D 2012, 'Young students learning formal algebraic notation and solving linear equations: Are commonly experienced difficulties avoidable?', *Educational Studies in Mathematics*, vol. 81, no. 2, pp. 139–159. https://doi.org/10.1007/s10649-012-9394-x

Hunicke, R, LeBlanc, M & Zubek, R 2004, 'MDA: A formal approach to game design and game research', *Proceedings of the Game Developers Conference*, San Jose, California, United States of America, 23 November, pp. 1–5.

Janvier, C 1987, *Problems of representation in the teaching and learning of mathematics*, Erlbaum, Hillsdale.

Kokkinaki, AI, Christoforos, A & Melanthiou, Y 2015, 'Integrating open educational resources to foster serious games and gamification design principles', *Ninth Mediterranean Conference on Information Systems*, Samos, viewed 26 August 2022, <https://aisel.aisnet.org/mcis2015/23/>

Kyewski, E & Krämer, NC 2018, 'To gamify or not to gamify? An experimental field study of the influence of badges on motivation, activity, and performance in an online learning course', *Computers & Education*, vol. 118, pp. 25–37. https://doi.org/10.1016/j.compedu.2017.11.006

Larson, K 2020, 'Serious games and gamification in the corporate training environment: A literature review', *TechTrend*, vol. 64, pp. 319–328. https://doi.org/10.1007/s11528-019-00446-7

Lindberg, S 2019, 'Gamification for self-directed learning in higher education', *EDULEARN19 Proceedings 11th International Conference on Education and New Learning Technologies,* Palma, Spain, 01–03 July, pp. 1764–1773. https://doi.org/10.21125/edulearn.2019.0507

MacGregor, M & Stacey, K 1993, 'Cognitive models underlying students' formulation of simple linear equations', *Journal for Research in Mathematics Education*, vol. 24, no. 3, pp. 217–232. https://doi.org/10.5951/jresematheduc.24.3.0217

Mahmud, SND, Husnin, H & Tuan Soh, TM 2020, 'Teaching presence in online gamified education for sustainability learning', *Sustainability*, vol. 12, p. 3801. https://doi.org/10.3390/su12093801

Mainali, B 2021, 'Representation in teaching and learning mathematics', *International Journal of Education in Mathematics, Science, and Technology*, vol. 9, no. 1, pp. 1–21. https://doi.org/10.46328/ijemst.1111

Marczewski, A 2015, *Even ninja monkeys like to play: Gamification, game thinking and motivational design*, CreateSpace Independent Publishing Platform, London.

Maree, K 2020, 'Planning a research proposal', in K Maree (ed.), *First steps in research*, 3rd edn., Van Schaik, Pretoria, pp. 26–53.

Nurmi, J, Knittle, K, Ginchev, T, Khattak, F, Helf, C, Zwickl, P, Castellano-Tejedor, C, Lusilla-Palacios, P, Costa-Requena, J, Ravaja, N & Haukkala, A 2020, 'Engaging users in the behavior change process with digitalized motivational interviewing and gamification: Development and feasibility testing of the precious app', *JMIR mHealth uHealth*, vol. 8, a12884. https://doi.org/10.2196/12884

Olivier, J 2021, 'Online access and resources for open self-directed learning in Africa', in D Burgos & J Olivier (eds.), *Radical solutions for education in Africa: Open education and self-directed learning in the continent*, lecture notes in Educational Technology, Springer, Singapore, pp. 1–16. https://doi.org/10.1007/978-981-16-4099-5_1

Ozgun-Koca, SA 1998, 'Students' use of representations in mathematics education', *Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, Raleigh, North Carolina, United States of America, 31 October–02 November, n.p.

Palaniappan, K & Noor, NM 2022, 'Gamification strategy to support self-directed learning in an online learning environment', *International Journal of Emerging Technologies in Learning*, vol. 17, no. 3, pp. 104–116. https://doi.org/10.3991/ijet.v17i03.27489

Pawley, D, Ayres, P, Cooper, M & Sweller, J 2005, 'Translating words into equations: A cognitive load theory approach', *Educational Psychology*, vol. 25, no. 1, pp. 75–97. https://doi.org/10.1080/0144341042000294903

Perelman, Y 1957, *Figures for fun stories and conundrums*, Foreign Languages Publishing House, Beijing.

Perelman, Y 1979, *Mathematics can be fun*, Mir Publishers, Moscow.

Risko, EF & Gilbert, SJ 2016, 'Cognitive offloading', *Trends in Cognitive Sciences*, vol. 20, no. 9, pp. 676–688. https://doi.org/10.1016/j.tics.2016.07.002

Robson, K, Plangger, K, Kietzmann, JH, McCarthy, I & Pitt, L 2016, 'Game on: Engaging customers and employees through gamification', *Business Horizons*, vol. 59, no. 1, pp. 29–36. https://doi.org/10.1016/j.bushor.2015.08.002

Sailer, M & Homner, L 2020, 'The gamification of learning: A meta-analysis', *Educational Psychology Review*, vol. 32, no. 1, pp. 77–112. https://doi.org/10.1007/s10648-019-09498-w

Sardi, L, Idri, A & Fernández-Alemán, JL 2017, 'A systematic review of gamification in e-Health', *Journal of Biomedical Informatics*, vol. 71, pp. 31–48. https://doi.org/10.1016/j.jbi.2017.05.011

Sipone, S, Abella-García, V, Barreda, R & Rojo, M 2019, 'Learning about sustainable mobility in primary schools from a playful perspective: A focus-group approach', *Sustainability*, vol. 11, p. 2387. https://doi.org/10.3390/su11082387

Stylianou, DA 2008, 'Representation as a cognitive and social practice', viewed 12 July 2023, <pme32-volume4-libre.pdf (d1wqtxts1xzle7.cloudfront.net)>

Superfine, AC, Canty, RS & Marshall, AM 2009, 'Translation between external representation systems in mathematics: All-or-none or skill conglomerate?', *The Journal of Mathematical Behavior*, vol. 28, no. 4, pp. 217–236. https://doi.org/10.1016/j.jmathb.2009.10.002

Trigueros, R, Aguilar-Parra, JM, López-Liria, R, Cangas, AJ, González, JJ & Álvarez, JF 2020, 'The role of perception of support in the classroom on the students' motivation and emotions: The impact on metacognition strategies and academic performance in math and English classes', *Frontiers in Psychology*, vol. 10, a2794. https://doi.org/10.3389/fpsyg.2019.02794

Trigueros, R, Aguilar-Parra, JM, López-Liria, R & Rocamora, P 2019, 'The dark side of the self-determination theory and its influence on the emotional and cognitive processes of students in physical education', *International Journal of Environmental Research and Public Health*, vol. 16, no. 22, a4444. https://doi.org/10.3390/ijerph16224444

Tsai, CY, Lin, HS & Liu, SC 2020, 'The effect of pedagogical GAME model on students' PISA scientific competencies', *Journal of Computer Assisted Learning*, vol. 36, no. 3, pp. 359–369. https://doi.org/10.1111/jcal.12406

United Nations Educational, Scientific and Cultural Organization (UNESCO) 2019, *Recommendation on open educational resources (OER)*, viewed 26 August 2022, <https://unesdoc.unesco.org/ark:/48223/pf0000373755/PDF/373755eng.pdf.multi.page=3>

Verschaffel, L, Schukajlow, S, Star, J & Van Dooren, W 2020, 'Word problems in mathematics education: A survey', *ZDM Mathematics Education*, vol. 52, pp. 1–16. https://doi.org/10.1007/s11858-020-01130-4

Vlassis, J 2002, 'The balance model: Hindrance or support for the solving of linear equations with one unknown', *Educational Studies in Mathematics*, vol. 49, pp. 341–359. https://doi.org/10.1023/A:1020229023965

Chapter 8

Annandale, M & Reyneke, EM 2020, 'The effect of skinny cow condition on first-year students' expectation of assessment and feedback', *Per Linguam*, vol. 36, pp. 45–56. https://doi.org/10.5785/36-2-949

Atta, IS & Alghamdi, AH 2018, 'The efficacy of self-directed learning versus problem-based learning for teaching and learning ophthalmology: A comparative study', *Advances in Medical Education and Practice*, vol. 9, pp. 623–630. https://doi.org/10.2147/AMEP.S171328

Beijaard, D, Verloop, N & Vermunt, J 2000, 'Teachers' perceptions of professional identity: An exploratory study from a personal knowledge perspective', *Teaching and Teacher Education*, vol. 16, no. 7, pp. 749–764. https://doi.org/10.1016/S0742-051X(00)00023-8

Benson, B 1997, 'Scaffolding (coming to terms)', *English Journal*, vol. 86, no. 7, pp. 126–127. https://doi.org/10.2307/819879

Bergdahl, N & Bond, M 2022, 'Negotiating (dis-)engagement in K-12 blended learning', *Education and Information Technologies*, vol. 27, no. 2, pp. 2635–2660. https://doi.org/10.1007/s10639-021-10714-w

Botha, CS 2021, 'Turning windows into mirrors: Digital stories as a teaching strategy to explore the apprenticeship of observation in pre-service teachers', *International Journal of Learning, Teaching and Educational Research*, vol. 20, no. 11, pp. 1–16. https://doi.org/10.26803/ijlter.20.11.1

Botha, CS & Reyneke, EM 2020, '"WIL goes PoP": The role of a professional orientation programme in addressing the apprenticeship of observation in first-year Bachelor of Education students', in J de Beer, N Petersen & HJ van Vuuren (eds.), *Becoming a teacher: Research on the work-integrated learning of student teachers*, NWU Self-Directed Learning Series, vol. 4, AOSIS Books, Cape Town. https://doi.org/10.4102/aosis.2020.BK215.08

Brenner, E 2016, 'Changing mindsets: Moving from the acceptance of facts to critical thinking', in J Arvanitakis & DJ Hornsby (eds.), *Universities, the citizen scholar and the future of higher education*, Palgrave Macmillan, London.

Brookfield, S 1986, *Understanding and facilitating adult learning*, Jossey-Bass, San Francisco.

Creswell, JW & Cresswell, JD 2017, *Research design: Qualitative, quantitative, and mixed methods approaches*, SAGE, London.

Crotty, M 1998, *The foundations of social research: Meaning and perspectives in research process*, SAGE, London.

Darling-Hammond, L 2006, 'Constructing 21st-century teacher education', *Journal of Teacher Education*, vol. 57, no. 3, pp. 1–15. https://doi.org/10.1177/0022487105285962

Darling-Hammond, L & Bransford, B 2006, *Preparing teachers for a changing world: What teachers should learn and be able to do*, Jossey-Bass, San Francisco.

Dayan, U, Khan, MI & Ahmad, S 2022, 'Transformation of prospective teachers' pedagogical beliefs during a pre-service BEd programme in Pakistan', *International Journal of Education and Practice*, vol. 10, no. 2, pp. 150–159. https://doi.org/10.18488/61.v10i2.3003

De Beer, J & Gravett, S 2016, 'The affordances of case-based teaching for self-directed learning: A case study with first-year student teachers', in E Mentz & I Oosthuizen (eds.), *Self-directed learning research*, AOSIS Books, Cape Town, pp. 35–71. http://dx.doi.org/10.4102/aosis.2016.sdlr14.02

Dlamini, BO, Tom, RF, Nel, KA & Zogli, LJ 2020, 'Adjustment experiences of first-year students in South Africa', *Academy of Educational Leadership Journal*, vol. 24, no. 6, pp. 1–10. https://hdl.handle.net/10321/4143

Freire, P 1970, *Pedagogy of the oppressed*, Continuum, New York.

Gillett-Swan, J 2017, 'The challenges of online learning: Supporting and engaging the isolated learner', *Journal of Learning Design*, vol. 10, no. 1, pp. 20–30. https://doi.org/10.5204/jld.v9i3.293

Gordon, G 2014, 'Well played: The origins and future of playfulness', *American Journal of Play*, vol. 6, no. 2, pp. 234–266.

Greenwalt, KA 2014, 'Frustrated returns: Biography, parental figures, and the apprenticeship of observation', *Curriculum Inquiry*, vol. 44, no. 3, pp. 306–331. https://doi.org/10.1111/curi.12048

Guitard, P, Ferland, F & Dutil, E 2005, 'Toward a better understanding of playfulness in adults', *Occupation, Participation and Health*, vol. 25, no. 1, pp. 9–22. https://doi.org/10.1177/153944920502500103

Hendricks, TS 2015, *Play and the human condition*, University of Illinois Press, Urbana.

Hennink, M, Hutter, I & Bailey, A 2020, *Qualitative research methods*, 2nd edn., SAGE Publications, Los Angeles.

Hmelo-Silver, CE 2004, 'Problem-based learning: How and what do students learn?', *Educational Psychology Review*, vol. 16, no. 3, pp. 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Holt, NL, Lee, H, Millar, CA & Spence, JC 2015, '"Eyes on where children play": A retrospective study of active free play', *Children's Geographies*, vol. 13, no. 1, pp. 73–88. https://doi.org/10.1080/14733285.2013.828449

Jackson, D 2016a, 'Developing pre-professional identity in undergraduates through work-integrated learning', *Higher Education*, vol. 74, no. 5, pp. 833–853. https://doi.org/10.1007/s10734-016-0080-2

Jackson, D 2016b, 'Re-conceptualising graduate employability: The importance of pre-professional identity', *Higher Education Research & Development*, vol. 35, no. 5, pp. 925–939. https://doi.org/10.1080/07294360.2016.1139551

Jacquelyn, M, Urbani, M, Roshandel, S, Michaels, R & Truesdell, E 2017, 'Developing and modeling 21st-century skills with pre-service teachers', *Teacher Education Quarterly,* vol. 44, no. 4, pp. 27–50.

Keung, CPC & Cheung, ACK 2019, 'Towards holistic supporting of play-based learning implementation in kindergartens: A mixed method study', *Early Childhood Education Journal*, vol. 47, pp. 627–640. https://doi.org/10.1007/s10643-019-00956-2

Khoiriyah, AJ & Hussamah, A 2018, 'Problem-based learning: Creative thinking skills, problem-solving skills, and learning outcome of seventh-Grade students', *Indonesian Journal of Biology Education*, vol. 4, no. 2, pp. 151–160. https://doi.org/10.22219/jpbi.v4i2.5804

Knowles, M 1975, *Self-directed learning: A guide for learners and teachers*, Follett Publishing Company, Chicago.

Leather, M, Harmper, N & Obee, P 2021, 'A pedagogy of play: Reasons to be playful in postsecondary education', *Journal of Experiential Education*, vol. 44, no. 3, pp. 208–226. https://doi.org/10.1177/1053825920959684

Lortie, CD 1975, *Schoolteacher: A sociological study*, University of Chicago Press, Chicago, Illinois.

Manuel, J & Hughes, J 2006, '"It has always been my dream": Exploring pre-service teachers' motivations for choosing to teach', *Teacher Development*, vol. 10, no. 1, pp. 5–24. https://doi.org/10.1080/13664530600587311

Marais, E 2021, 'A journey through digital storytelling during COVID-19: Students' preparedness to use technology for learning in the language classroom', *Research in Social Sciences and Technology*, vol. 6, no. 2, pp. 169–182. https://doi.org/10.46303/ressat.2021.17

Merriam, SB, Caffarella, RS & Baumgartner, LM 2007, *Learning in adulthood: A comprehensive guide*, John Wiley & Sons, San Francisco.

Nasri, N 2017, 'Self-directed learning through the eyes of teacher educators', *Kasetsart Journal of Social Sciences*, vol. 40, no. 1, pp. 1–8. https://doi.org/10.1016/j.kjss.2017.08.006

Nolan, A & Paatsch, L 2017, '(Re)affirming identities: Implementing a play-based approach to learning in the early years of schooling', *International Journal of Early Years Education*, vol. 26, no. 1, pp. 42–55. https://doi.org/10.1080/09669760.2017.1369397

Palinkas, LA, Horwitz, SM, Green, CA, Wisdom, JP, Duan, N & Hoagwood, K 2015, 'Purposeful sampling for qualitative data collection and analysis in mixed method implementation research', *Administration and Policy in Mental Health and Mental Health Services Research*, vol. 42, no. 5, pp. 533–544. https://doi.org/10.1007/s10488-013-0528-y

Petersen, N & De Beer, J 2019, 'The forest in my hand: Student teachers' experiences of engaging in an educational excursion', *8th Teaching & Education Conference*, Vienna, Austria, September, n.p.

Rantsi, T 2016, *Transitioning from secondary school to tertiary education: What social investors should know*, viewed 13 July 2023, <https://cornerstone.ac.za/transitioning-from-secondary-school-to-tertiary-education-what-social-investors-should-know/>

Republic of South Africa (RSA) 2015, *Revised policy on the minimum requirements for teacher education qualifications*, Government Printing Works, Pretoria.

Rinke, CR, Mawhinney, L & Park, G 2013, 'The apprenticeship of observation in career contexts: A typology for the role of modeling in teachers' career paths', *Teachers and Teaching*, vol. 20, no. 1, pp. 92–107. https://doi.org/10.1080/13540602.2013.848517

Rogers, CR 1983, *Freedom to learn for the 80s*, Merrill Publishing, Columbus.

Roller, MR & Lavrakas, PJ 2005, *Applied qualitative research design: A total quality framework approach*, The Guilford Press, New York.

Rotherham, A & Willingham, D 2009, '21st-century skills: Not new, but a worthy challenge', *Educational Leadership*, vol. 67, no. 1, pp. 16–21.

Shulman, LS 1986, 'Those who understand: Knowledge growth in teaching', *Educational Researcher*, vol. 15, no. 2, pp. 4–14. https://doi.org/10.3102/0013189X015002004

Šimůnková, K 2018, 'Hybrid ludic engagement: A manifesto', *Social Studies*, vol. 15, no. 2, pp. 119–143.

Siviy, SM 2016, 'A brain motivated to play: Insights into the neurobiology of playfulness', *Behaviour*, vol. 153, nos. 6–7, pp. 819–844. https://doi.org/10.1163/1568539X-00003349

Smagorinsky, P & Barnes, ME 2014, 'Revisiting and revising the apprenticeship of observation', *Teacher Education Quarterly*, vol. 41, no. 4, pp. 29–52.

Solis, L, Khumalo, K, Nowack, S, Blythe-Davidson, E & Mardell, B 2019, *Towards a South African pedagogy of play*, viewed 13 July 2023, <http://www.pz.harvard.edu/sites/default/files/Pedagogy%20of%20Play%20South%20Africa_Working%20Paper%20Final_Mar%207.pdf>

Teo, P 2019, 'Teaching for the 21st century: A case for dialogic pedagogy', *Learning, Culture and Social Interaction*, vol. 21, pp. 170–178. https://doi.org/10.1016/j.lcsi.2019.03.009

LEGO® Foundation 2020, 'The invention of Six BRICKS', video recording, LEGO® Foundation, viewed 30 May 2022, <https://vimeo.com/314016762>

LEGO® Foundation 2021a, *It's time to rethink learning*, viewed 29 September 2022, <https://education.lego.com/en-us/itstimetorethinklearning>

LEGO® Foundation 2021b, *South Africa*, viewed 30 June 2022, <https://www.legofoundation.com/en/about-us/focus-geographies/south-africa/>

Chapter 9

Ackerman, E 2021, *Choosing dramatic arts: Everything you need to know*, viewed 03 January 2022, <https://www.impaq.co.za/blog/choosing-dramatic-arts-everything-you-need-to-know/>

Amer, AA 2003, 'Teaching EFL/ESL literature', *Reading Matrix: An International Online Journal*, vol. 3, no. 2, pp. 63–73.

Baldwin, P 2015, *Drama strategies and conventions*, viewed 20 October 2022, <https://patricebaldwin.files.wordpress.com/2015/08/drama-strategies-and-conventions-booklet-2.pdf>

Beckers, J, Dolmans, D & Van Merriënboer, J 2016, 'e-Portfolios enhancing students' self-directed learning: A systematic review of influencing factors', *Australasian Journal of Educational Technology*, vol. 32, no. 2, pp. 32–46. https://doi.org/10.14742/ajet.2528

Berry, R 2011, 'Assessment reforms around the world', in R Berry & RB Adamson (eds.), *Assessment reform in education: Policy and practice*, Springer, New York, pp. 89–104.

Collie, J & Slater, S 1990, *Literature in the language classroom*, Cambridge University Press, Cambridge.

Creswell, JW 2003, *Research design: Qualitative, quantitative and mixed-methods approaches*, SAGE Publications, Newbury Park.

Department of Basic Education (DBE) 2011a, *CAPS Grades 10–12 English Home Language*, Government Printing Works, Pretoria.

Department of Basic Education (DBE) 2011b, *CAPS Grades 10–12 Dramatic Arts*, Government Printing Works, Pretoria.

Dunn, J & Stinson, M 2011, 'Not without art!! The importance of teacher artistry when applying drama as pedagogy for additional language learning', *The Journal of Applied Theatre and Performance*, vol. 16, no. 4, pp. 617–633. https://doi.org/10.1080/13569783.2011.617110

Edmonds, WA & Kennedy, TD 2017, 'Convergent-parallel approach', in WA Edmonds & TD Kennedy (eds.), *An applied guide to research designs: Quantitative, qualitative and mixed methods*, SAGE Publications, Newbury Park, pp. 181–188. https://www.doi.org/10.4135/9781071802779

Faizah, R, Taqwa, MRA, Istiyono, E & Ikhsanudin, I 2021, 'Senior high school student's higher-order thinking skills based on gender and grade', *Journal of Physics: Conference Series*, vol. 1918, no. 2, a022031. https://doi.org/10.1088/1742-6596/1918/2/022031

Frey, B 2018, *The SAGE encyclopedia of educational research, measurement, and evaluation*, SAGE Publications, Thousand Oaks. https://doi.org/10.4135/9781506326139.

Gillian, L 1999, 'Literature and language teaching; exploring literary text with the language learner', *TESOL Quarterly*, vol. 30, no. 4, pp. 773–776. https://doi.org/10.2307/3587934.

Gönen, SIK 2018, *Implementing poetry in the language class: A poetry-teaching framework for prospective English language teachers*, Department of English Language Teaching, Anadolu University, viewed 12 July 2021, <https://files.eric.ed.gov/fulltext/EJ1199017.pdf>

Grosser, M & Nel, M 2013, 'The relationship between the critical thinking skills and the academic language proficiency of prospective teachers', *South African Journal of Education*, vol. 33, no. 2, pp. 1–17. https://doi.org/10.15700/saje.v33n2a639

Grow, GO 1991, 'Teaching learners to be self-directed', *Adult Education Quarterly*, vol. 41, no. 3, pp. 125–149. https://doi.org/10.1177/0001848191041003001

Guglielmino, LM 2013, 'The case for promoting self-directed learning in formal education institutions', *SA-eDUC Journal*, vol. 10, no. 2, pp. 1–18.

Hellemann, P 2022, 'Towards a problem-posing pedagogy: Using teacher-in-role in a special needs classroom', *South African Journal of Childhood Education*, vol. 12, no. 1, a1205. https://doi.org/10.4102/sajce.v12i1.1205

Hişmanoğlu, M 2005, 'Teaching English through literature', *Journal of Language and Linguistic Studies*, vol. 1, no. 1, pp. 53–66.

Jennett, PA 1992, 'Self-directed learning: A pragmatic view', *Journal of Continuing Education in the Health Professions*, vol. 12, pp. 99–104. https://doi.org/10.1002/chp.4750120208

Jordaan, P 2015, 'Finding creativity: Integrating drama teaching techniques in creative writing lessons', MEd thesis, Stellenbosch University, Stellenbosch.

Kemp, K, Baxa, D & Cortes, C 2022, 'Exploration of a collaborative self-directed learning model in medical education', *Medical Science Educator*, vol. 32, no. 1, pp. 195–207. https://doi.org/10.1007/s40670-021-01493-7

Knowles, MS 1975, *Self-directed learning: A guide for learners and teachers*, Association Press, New York.

Kobayashi, D 2012, 'Drama techniques in the EFL classroom', *Mask & Gavel*, vol. 1, pp. 30–33. https://doi.org/10.37546/JALTSIG.PIE1.1-4

Li, Y & Fan, ZH 2019, 'Enhance student learning motivation through literature in English teaching', *Higher Education of Social Science*, vol. 17, no. 1, pp. 36–41. https://doi.org/10.3968/11424

Maree, K & Pietersen, J 2016, 'The quantitative research process', in K Maree (ed.), *First steps in research*, 2nd edn., Van Schaik Publishers, Pretoria, pp. 161–172.

Mart, CT 2019, 'Reader-response theory and literature discussions: A springboard for exploring literary texts', *The New Educational Review*, vol. 56, no. 2, pp. 78–87. https://doi:10.15804/tner.2019.56.2.06

McIntyre, C, Olivier, SJ & Varga, E 2015, *Imagined worlds: An anthology of poetry Grade 12*, Macmillan Education, Johannesburg.

Mentz, E & Van Zyl, S 2018, 'The impact of cooperative learning on self-directed learning abilities in the computer applications technology class', *International Journal of Lifelong Education*, vol. 37, no. 4, pp. 482–494. https://doi.org/10.1080/02601370.2018.1513426

Monyai, SC 2010, 'Meeting the challenges of black second-language English South African learners in ex-model C primary schools', mini-MA thesis, University of Pretoria, Pretoria, viewed 17 September 2023, <http://hdl.handle.net/2263/24289>.

Patall, EA, Lee, BK, Cathon, SW & Steingut, RR 2015, 'The effect of drama-based pedagogy on preK-16 outcomes: A meta-analysis of research from 1985 to 2012', *Review of Educational Research*, vol. 85, no. 1, pp. 3–49. https://doi.org/10.3102/0034654314540477

Pushpa, VK & Savaedi, SY 2014, 'Teaching poetry in autonomous ELT classes', *Social and Behavioral Sciences*, vol. 98, pp. 1919–1925. https://doi.org/10.1016/j.sbspro.2014.03.623

Romylos, S 2020, 'Professional identities of English literature teachers in a South African context', *Changing English*, vol. 28, no. 1, pp. 1–17. https://doi.org/10.1080/1358684X.2020.1760082

Rosenblatt, L 1978, *The reader, the text, the poem: The transactional theory of literary work*, Southern Illinois University Press, Carbondale.

Shorten, A & Smith, J 2017, 'Mixed methods research: Expanding the evidence base', *Evidence-based Nursing*, vol. 20, pp. 74–75. http://dx.doi.org/10.1136/eb-2017-102699

Spirovska, E 2019, *Reader-response theory and approach: Application, values and significance for students in literature courses*, South-East European University Press, Tetvov.

Strydom, M 2019, 'Developing a framework for promoting self-directed learning in first-year English for education', MEd thesis, North-West University, Potchefstroom.

Syed, AJA & Wahas, YMA 2020, 'Challenges and solutions in teaching English through Poetry to EFL students at Hajjah University: A case study of William Wordsworth's Lucy and John Donne's Death Poems', *rEFLections*, vol. 27, no. 2, pp. 189–198. https://files.eric.ed.gov/fulltext/EJ1283272.pdf

Tohidi, S, Jamshidi, F, Ahmadinia, H, Shahdoust, M & Moonaghi, HK 2019, 'The relationship between self-directed learning and motive of progress and learning strategies in students of Hamedan University of Medical Sciences', *Journal of Medical Education*, vol. 18, no. 1, pp. 22–28.

Uysal, ND & Yavuz, F 2018, 'Language learning through drama', *International Journal of Learning and Teaching*, vol. 10, no. 4, pp. 376–380. https://doi.org/10.18844/ijlt.v10i4.766

Van der Walt, C & Evans, R 2019, *Learn 2 teach*, 5th edn., Van Schaik Publishers, Pretoria.

Van Heerden, J & Veldsman, A (eds.) 2021, *Rethinking learning through play*, 1st edn., Van Schaik Publishers, Pretoria.

Vygotsky, LS & Cole, M 1978, *Mind in society: The development of higher psychological processes*, Harvard University Press, Cambridge.

Widdowson, HG 1975, *Stylistics and the teaching of literature*, Longman, London.

Williamson, SN 2007, 'Development of a self-rating scale of self-directed learning', *Nurse Researcher*, vol. 14, no. 2, pp. 66–83. https://doi.org/10.7748/nr2007.01.14.2.66.c6022

Wisdom, J & Creswell, JW 2013, *Mixed methods: Integrating quantitative and qualitative data collection and analysis while studying patient-centered medical home models*, Agency for Healthcare Research and Quality, Rockville.

Chapter 10

Ackermann, E 2001, 'Piaget's constructivism, Papert's constructionism: What's the difference', *Future of Learning Group Publication*, vol. 5, pp. 1–11.

Angel-Fernandez, JM & Vincze, M 2018, 'Towards a definition of educational robotics', in P Zech & J Piater (eds.), *Austrian robotics workshop 2018*, Innsbruck University Press, Innsbruck, pp. 37–42. http://dx.doi.org/10.15203/3187-22-1-08

Anisimova, T, Sabirova, F & Shatunova, O 2020, 'Formation of design and research competencies in future teachers in the framework of STEAM education', *International Journal of Emerging Technologies in Learning*, vol. 15, pp. 204–217. https://doi.org/10.3991/ijet.v15i02.11537

Arís, N & Orcos, L 2019, 'Educational robotics in the stage of secondary education: Empirical study on motivation and STEM skills', *Education Sciences*, vol. 9, no. 2, pp. 1–15. https://doi.org/10.3390/educsci9020073

Badia, A & Iglesias, S 2019, 'The science teacher identity and the use of technology in the classroom', *Journal of Science Education and Technology*, vol. 28, no. 4, pp. 532–541. https://doi.org/10.1007/s10956-019-09784-w

Bressler, DM & Annetta, LA 2022, 'Using game design to increase teachers' familiarity with design thinking', *International Journal of Technology and Design Education*, vol. 32, no. 8, pp. 1023–1035. https://doi.org/10.1007/s10798-020-09628-4

Carvalho, MB, Bellotti, F, Berta, R, De Gloria, A, Sedano, CI, Hauge, JB, Hu, J & Rauterberg, M 2015, 'An activity theory-based model for serious games analysis and conceptual design', *Computers & Education*, vol. 87, pp. 166–181. https://doi.org/10.1016/j.compedu.2015.03.023

Chalmers, C 2018, 'Robotics and computational thinking in primary school', *International Journal of Child-Computer Interaction*, vol. 17, pp. 93–100. https://doi.org/10.1016/j.ijcci.2018.06.005

Chang, C-C & Chen, Y 2020, 'Using mastery learning theory to develop task-centered hands-on STEM learning of Arduino-based educational robotics: Psychomotor performance and perception by a convergent parallel mixed method', *Interactive Learning Environments*, vol. 30, no. 9, pp. 1677–1692. https://doi.org/10.1080/10494820.2020.1741400

Chiazzese, G, Arrigo, M, Chifari, A, Lonati, V & Tosto, C 2018, 'Exploring the effect of a robotics laboratory on computational thinking skills in primary school children using the bebras tasks', *Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality*, Association for Computing Machinery (ACM), New York, NY, United States of America, 24–26 October, pp. 25–30.

De Beer, JJ & Mentz, E 2017, ''n Kultuurhistoriese aktiwiteitsteoretiese blik op die houers van inheemse kennis as selfgerigte leerders: Lesse vir onderwys in Suid-Afrikaanse skole [A cultural-historical activity theory view of the holders of indigenous knowledge as self-directed learners: Lessons for education in South African schools]', *Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie*, vol. 36, no. 1, a1474. https://doi.org/10.4102/satnt.v36i1.1474

Di Battista, S, Pivetti, M, Moro, M & Menegatti, E 2020, 'Teachers' opinions towards educational robotics for special needs students: An exploratory Italian study', *Robotics*, vol. 9, no. 72, pp. 1–16. https://doi.org/10.3390/robotics9030072

Edwards, S 2017, 'Play-based learning and intentional teaching: Forever different?', *Australasian Journal of Early Childhood*, vol. 42, no. 2, pp. 4–11. https://doi.org/10.23965/AJEC.42.2.01

Engeström, Y 1987, '*Learning by expanding: An activity-theoretical approach to developmental research*', Orienta-Konsultit Oy, Helsinki.

Engeström, Y 1999, 'Activity theory and individual and social transformation', in Y Engeström, R Miettinen & R Punamaki (eds.), *Perspectives on activity theory*, vol. 19, Cambridge University Press, Cambridge, pp. 19–30. https://doi.org/10.1017/CBO9780511812774.003

Engeström, Y 2001, 'Expansive learning at work: Toward an activity theoretical reconceptualization', *Journal of Education and Work*, vol. 14, no. 1, pp. 133–156. https://doi.org/10.1080/13639080020028747

Engeström, Y 2009, *The future of activity theory: A rough draft*, Cambridge University Press, New York.

Evripidou, S, Georgiou, K, Doitsidis, L, Amanatiadis, AA, Zinonos, Z & Chatzichristofis, SA 2020, 'Educational robotics: Platforms, competitions and expected learning outcomes', *IEEE Access*, vol. 8, pp. 219534–219562. https://doi.org/10.1109/ACCESS.2020.3042555

Forbes, LK 2021, 'The process of play in learning in higher education: A phenomenological study', *Journal of Teaching and Learning*, vol. 15, no. 1, pp. 57–73. https://doi.org/10.22329/jtl.v15i1.6515

González, YAC & Muñoz-Repiso, AG-V 2018, 'A robotics-based approach to foster programming skills and computational thinking: Pilot experience in the classroom of early childhood education', in FJ García-Peñalvo (ed.), *Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality*, Association for Computing Machinery, New York, NY, United States of America, 24–26 October, pp. 41–45.

Guglielmino, LM 2013, 'The case for promoting self-directed learning in formal educational institutions', *SA-eDUC Journal*, vol. 10, no. 2, pp. 1–18.

Hadad, S, Shamir-Inbal, T, Blau, I & Leykin, E 2021, 'Professional development of code and robotics teachers through small private online course (SPOC): Teacher centrality and pedagogical strategies for developing computational thinking of students', *Journal of Educational Computing Research*, vol. 59, no. 4, pp. 763–791. https://doi.org/10.1177/0735633120973432

Higueras-Rodríguez, L, Medina-García, M & Molina-Ruiz, E 2020, 'Analysis of courses and teacher-training programs on playful methodology in Andalusia (Spain)', *Education Sciences*, vol. 10, no. 4, pp. 1–18. https://doi.org/10.3390/educsci10040105

Jaipal-Jamani, K & Angeli, C 2017, 'Effect of robotics on elementary preservice teachers' self-efficacy, science learning, and computational thinking', *Journal of Science Education and Technology*, vol. 26, pp. 175–192. https://doi.org/10.1007/s10956-016-9663-z

Kalogiannidou, A, Natsiou, G & Tsitouridou, M 2021, 'Robotics in early childhood education: Developing a framework for classroom activities', in S Papadakis & M Kalogiannakis (eds.), *Handbook of research on using educational robotics to facilitate student learning*, IGI Global, Hershey, pp. 402–423.

Kim, C, Kim, D, Yuan, J, Hill, RB, Doshi, P & Thai, CN 2015, 'Robotics to promote elementary education pre-service teachers' STEM engagement, learning, and teaching', *Computers & Education*, vol. 91, no. 3, pp. 14–31. https://doi.org/10.1016/j.compedu.2015.08.005

Knowles, MS 1975, *Self-directed learning: A guide for learners and teachers*, Association Press, New York.

Leontiev, AN 1978, *Activity, consciousness, and personality*, Prentice-Hall, Englewood Cliffs.

López-Belmonte, J, Segura-Robles, A, Moreno-Guerrero, A-J & Parra-González, M-E 2021, 'Robotics in education: A scientific mapping of the literature in Web of Science', *Electronics*, vol. 10, no. 3, pp. 1–18. https://doi.org/10.3390/electronics10030291

Majherová, J & Králík, V 2017, 'Innovative methods in teaching programming for future informatics teachers', *European Journal of Contemporary Education*, vol. 6, no. 3, pp. 390–400. https://doi.org/10.13187/ejced.2017.3.390

Mentz, E & De Beer, J 2019, 'The use of cultural-historical activity theory in researching the affordances of indigenous knowledge for self-directed learning', in J de Beer (ed.), *The decolonisation of the curriculum project: The affordances of indigenous knowledge for self-directed learning*, NWU Self-Directed Learning Series, vol. 2, AOSIS Books, Cape Town, pp. 49–86. https://doi.org/10.4102/aosis.2019.BK133.03

Nørgård, RT, Toft-Nielsen, C & Whitton, N 2017, 'Playful learning in higher education: Developing a signature pedagogy', *International Journal of Play*, vol. 6, no. 3, pp. 272–282. https://doi.org/10.1080/21594937.2017.1382997

Paaskesen, RB 2020, ‘Play-based strategies and using robot technologies across the curriculum’, *International Journal of Play*, vol. 9, no. 2, pp. 230–254. https://doi.org/10.1080/21594937.2020.1778272

Papert, S 1980, *Mindstorms, children, computers, and powerful ideas*, Basic Books, New York.

Penprase, BE 2018, ‘The Fourth Industrial Revolution and higher education’, in NW Gleason (ed.), *Higher education in the era of the Fourth Industrial Revolution*, Palgrave Macmillan, Singapore, pp. 207–229. https://doi.org/10.1007/978-981-13-0194-0

Piaget, J 1972, ‘Intellectual evolution from adolescence to adulthood’, *Human Development*, vol. 15, no. 1, pp. 1–12. https://doi.org/10.1159/000271225

Saldaña, J 2016, *The coding manual for qualitative researchers*, SAGE Publications, London.

Scaradozzi, D, Screpanti, L, Cesaretti, L, Storti, M & Mazzieri, E 2019, ‘Implementation and assessment methodologies of teachers’ training courses for STEM activities’, *Technology, Knowledge and Learning*, vol. 24, no. 2, pp. 247–268. https://doi.org/10.1007/s10758-018-9356-1

Schina, D, Esteve-González, V & Usart, M 2021, ‘An overview of teacher-training programs in educational robotics: Characteristics, best practices and recommendations’, *Education and Information Technologies*, vol. 26, pp. 2831–2852. https://doi.org/10.1007/s10639-020-10377-z

Schwab, K 2016, *The Fourth Industrial Revolution*, CROWN Business, New York.

Soanes, C & Stevenson, A 2004, *Concise Oxford English dictionary*, 11th edn., Oxford University Press, Oxford, pp. 1462, 1095.

Thorsted, AC, Bing, RG & Kristensen, M 2015, ‘Play as mediator for knowledge-creation in problem-based learning’, *Journal of Problem-Based Learning in Higher Education*, vol. 3, no. 1. https://doi.org/10.5278/ojs.jpblhe.v3i1.1203

Valsamidis, S, Giannoula Florou, G, Anastasiadou, S & Mandilas, A 2021, ‘Educational robotics as a teaching tool of information technology in the primary education’, *Proceedings of EDULEARN21 Conference*, virtual conference, 05–06 July, pp. 9806–9816. https://doi.org/10.21125/edulearn.2021.1984

Vygotsky, LS & Cole, M 1978, *Mind in society: The development of higher psychological processes*, Harvard University Press, Cambridge.

Wing, JM 2006, ‘Computational thinking’, *Communications of the ACM*, vol. 49, pp. 33–35. https://doi.org/10.1145/1118178.1118215

Wing, JM 2014, ‘Computational thinking benefits society’, in *Social issues in computing*, viewed 06 September 2022, <http://socialissues.cs.toronto.edu/index.html%3Fp=279.html>

Wong, FMF, Tang, ACY & Cheng, WLS 2021, ‘Factors associated with self-directed learning among undergraduate nursing students: A systematic review’, *Nurse Education Today*, vol. 104, p. 104998. https://doi.org/10.1016/j.nedt.2021.104998

World Economic Forum 2020, *The future of jobs report*, viewed 11 June 2022, <https://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf>

Zosh, JM, Hirsh-Pasek, K, Hopkins, EJ, Jensen, H, Liu, C, Neale, D, Solis, SL & Whitebread, D 2018, ‘Accessing the inaccessible: Redefining play as a spectrum’, *Frontiers in Psychology*, vol. 9, pp. 1–12. https://doi.org/10.3389/fpsyg.2018.01124

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This edited collection offers a compelling examination of how to use games and play to teach. With an interdisciplinary and international focus, this book critically meets a growing international demand within academia to educate using games. Teaching effectively utilising games is difficult, especially from a global and cross-disciplinary perspective, making this book's diverse pedagogical perspectives essential to scholarship.

Dr Rebekah Shultz Colby, Department of Undergraduate Studies, Writing Programme, University of Denver, Denver, Colorado, United States of America

The chapters in this book cover different aspects of building engaging pedagogies and active learning. Aspects include problem-based learning, interactive pedagogy of play, joyful learning, game-based tasks, computational thinking, using puzzles, developing teacher identity and cultural facets. The book also provides theoretical foundations and practical examples of integrating these practices into various subjects and grade levels. One of the most important – and probably most challenging – developments in teaching currently is the production of 21st-century skills such as critical thinking, creativity and problem-solving through self-directed learning.

This book provides scholarly recommendations on strategies for active engagement in teaching and learning. It implements a holistic approach to developing self-directed learning, especially in the mathematics discipline. These recommendations can enhance self-directed learning, not only for future challenges but for current challenges faced in the educational environment. This publication will also spur scholarly research in this new and challenging field.

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