



**Diverse educational contexts  
and research on metacognition  
and motivation to enhance  
self-directed learning**

Edited by

**Bernadette Geduld, Byron J Bunt & Divan Jagals**

NWU Self-Directed Learning Series  
Volume 13

**Diverse educational contexts  
and research on metacognition  
and motivation to enhance  
self-directed learning**



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The publisher (AOSIS) endorses the South African 'National Scholarly Book Publishers Forum Best Practice for Peer-Review of Scholarly Books'. The 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 editor and were independent of the volume editor, with the identities of the reviewers not revealed to the editor(s) or author(s). The reviewers were independent of the publisher, editor(s) and author(s). The publisher shared feedback on the similarity report and the reviewers' inputs with the manuscript's editor(s) or author(s) to improve the manuscript. Where the reviewers recommended revision and improvements, the editor(s) or author(s) 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

This book is devoted to original academic studies in the subject of education, with a focus on using metacognition research to increase self-directed learning (SDL). In the North-West University (NWU) SDL book series, this is the thirteenth volume. Developing students' metacognitive and self-directed learning skills equips them for effective functioning in the 21st century. Metacognition is crucial for planning, evaluating and self-assessing the learning process. It promotes reflective and independent thinking, helping students apply their understanding to new contexts. Research shows that students with strong metacognitive skills achieve higher learning outcomes and exhibit better self-directed learning. Metacognitive strategies increase students' awareness and control over their learning, enhancing their capacity for self-regulation, motivation management and persistence in learning.

This book adds new knowledge by exploring how teachers and lecturers can support the development of metacognition and motivation to enhance self-directed learning in various educational contexts. Teacher behaviours and teaching strategies are explored further in a broad domain of research that promote metacognitive skills, self-regulated learning skills and motivation for self-directed learning. A qualitative research methodology was applied.

This book extends the research in educational, developmental, cognitive and applied psychology by exploring these across the South African education landscape. Key research questions emerging in basic and higher education are addressed, answering these questions by assessing major theoretical themes and applying them in the research field. Research on the use and understanding of metacognition in several different disciplines is also included. Chapters in the book also define the scope of metacognition and cover its historical origins along with current implications for future research.

The chapters form a cohesive contribution to the literature on metacognition and self-directed learning across various educational contexts. While each chapter represents independent research, the publication collectively offers diverse viewpoints on the importance of developing these skills. The authors address key research issues in both basic and higher education. The preface includes a thorough explanation of how each chapter fits into the overall focus of the book, as well as a detailed explanation of how each chapter advances the use of metacognition to improve SDL in dynamic and complex educational environments. The following chapters are based on MA and PhD thesis, and a conference proceeding, and the necessary acknowledgement is provided within the chapter: 'Metacognition: The cognitive and affective architecture of self-directed learning' by Divan Jagals; 'Metacognitive reflection based on a selection of history game genres to develop self-directed learning' by Byron J Bunt, Lance R Bunt and Michael Stack; 'Modelling metacognitive monitoring skills and self-regulated learning: Teacher experiences in selected secondary schools' by Vanishree Ragvan and Bernadette Geduld; 'Exploring how metacognition and motivation influence classroom environments to enhance successful learning in accounting' by Alviné Petzer; 'Grade 7 mathematics learners' metacognitive thinking in problem-based tasks' by Sylvia Kashango, Marietjie Havenga and Tertia Jordaan; and 'Proposing a model for analysing the relationship between metacognitive awareness and worldview as mediating constructs of self-directed learning' by Christine-Marie van der Westhuizen, Divan Jagals and Marisa (MC) Verster.

The target audience is scholars involved in teaching, and teacher training, in the field of self-directed learning, metacognition and self-regulated learning in education

who will all benefit from the theoretical and practical suggestions provided in the book.

This publication was prepared through a meticulous double-blind peer-review process. As mandated by the Department of Higher Education and Training, over 50% of the content in this book is original and has not been published before. Additionally, every effort was made to guarantee that no portion of the book has been plagiarised.

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

## List of abbreviations and acronyms

AECC	Accounting Education Change Commission
AI	artificial intelligence
AICPA	American Institute of Certified Public Accountants
ASA	Accountancy South Africa
CAPS	Curriculum and Assessment Policy Statement
CAQDAS	computer-assisted qualitative data analysis software
CI	confidence interval
DBE	Department of Basic Education
DBR	design-based research
EduREC	Education Sciences Research Ethics Committee
EMS	Economic Management Sciences
FET	Further Education and Training
GBL	game-based learning
HEI	higher education institutions
HoD	Heads of Departments
HOT	higher order thinking
IACE	Institute for the Advancement of Cognitive Education
IBL	inquiry-based learning
IJEMST	International Journal of Education in Mathematics, Science, and Technology
IJIM	International Journal of Interactive Mobile
KZN	KwaZulu-Natal
NCTM	National Council for Mathematics Teachers (Namibia)
NIED	National Institute for Educational Development (Namibia)
NRF	National Research Foundation
NSC	National Senior Certificate
NWU	North-West University
PBL	problem-based learning
PCK	Pedagogical Content Knowledge

PCL	problem-centred learning
PIRLS	Progress in International Reading Literacy Studies
PST	pre-service teachers
RAMPS	regulated attention in mathematical problem solving
RDGC	Research Data Gatekeepers Committee
RME	realistic mathematics education
RMSEA	root mean square error of approximation
SDL	self-directed learning
SETH	Science, Engineering, Technology & Health
SGB	school governing body
SLD	students with learning disabilities
SMT	school management teams
SRL	self-regulated learning
TIMSS	Trends in International Mathematics and Science Study
ZPD	Zone of Proximal Development

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# Foreword

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The book, *Diverse educational contexts and research on metacognition and motivation to enhance self-directed learning*, is timely because of the growing importance of self-directed learning in contemporary educational settings. With the increasing emphasis on personalised and flexible learning approaches, self-directed learning has become a critical skill for students across diverse educational contexts.

This book addresses the need for comprehensive insights into metacognition and motivation, key factors influencing self-directed learning. It extensively investigates metacognition and motivation in self-directed learning in an era of dynamic educational reforms and fast-emerging learning paradigms. Metacognition and self-directed learning are necessary for developing 21st-century abilities such as critical thinking, problem-solving, creativity and adaptability. This book provides academics and teachers with the tools and information they need to assist students in acquiring these abilities, making it highly relevant in today's fast-changing world. This collection of chapters weaves together a rich tapestry of research and practical insights that highlight the significance of metacognition and give educators, academics and students valuable tools for fostering self-directed learning in various educational contexts.

The very foundation of education has shifted towards allowing students to take charge of the learning process, and metacognition has emerged as a critical component of this transformation. Therefore, this book explores the complexities of metacognition and its function in self-directed learning, thoroughly explaining how metacognitive practices may improve students' cognitive awareness, self-regulation and motivation. The well-researched chapters in this book demonstrate the link between metacognition and self-directed learning, providing light on the benefits of metacognitive abilities in obtaining more significant levels of learning accomplishment and self-directed learning.

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The chapters cover various areas such as mathematics, language and problem-solving in different educational situations ranging from basic to higher education. The chapters in this book highlight the importance of metacognition and motivation in various educational disciplines. These chapters provide practical insights and research-informed methodologies for using the 'Six Thinking Hats' strategy to cultivate metacognitive self-directed learning in pre-service teachers, integrating metacognition in mathematical education and exploring game-based learning for metacognitive development. The authors also discuss the role of academics and teachers in modelling metacognitive abilities, making this book a valuable resource for academics and teachers who want to encourage their students to become self-directed learners. This book highlights the significance of teacher behaviour and instructional approaches in encouraging metacognition and motivation in students and providing them with the skills they need to succeed.

Furthermore, this book explores the critical interplay between metacognition, motivation and self-directed learning, offering research data demonstrating these elements' tremendous influence on successful learning. It shows how students' metacognitive awareness and abilities are critical in establishing perseverance, motivation and engagement, which leads to enhanced learning outcomes. This book is an educational resource for higher education academics, teachers and students that provides both theoretical insights and practical solutions. It emphasises the modern relevance of metacognition in influencing the future of education and preparing students with the skills and qualities required for a fast-changing world.

# Preface

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The process of self-directed learning (SDL) is a complex and multifaceted endeavour, including many educational settings, metacognitive strategies and motivating factors. At the juncture of these fundamental elements, we are now on a noteworthy journey that reshapes our comprehension of education, metacognition, self-regulated learning and motivation.

This scholarly publication, titled *Diverse educational contexts and research on metacognition and motivation to enhance self-directed learning*, extensively explores the complex terrain of SDL, emphasising the essential interaction between metacognition, self-regulated learning and motivation. The investigation we embark upon encompasses a variety of educational environments, each serving as a distinct venue for fostering individuals who can direct their own learning.

The contemporary educational environment has seen a departure from conventional classroom settings, as SDL has emerged as a significant influence in steering education in the 21st century. The metacognitive processes that assist learners in establishing objectives, assessing their progress and adjusting their tactics are essential components of this transition. Concurrently, motivation serves as the catalyst that encourages people to begin their educational endeavours, maintain their exertions and persist amid obstacles.

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Chapter 1 expounds on a conceptual framework for metacognition, looking at the cognitive and affective architecture of SDL. Metacognition and SDL research seem to be at a turning point in 21st-century education. The belief that learners, parents and pre- and in-service teachers must find and support (sometimes unique) learning requirements, objectives and processes necessitates exploring the growing body of research on the issue. Early work by Knowles (Knowles 1973, p. 103) contrasts Newtonian and Einsteinian systems' conceptions of learning, a key source of SDL. The author compares Newtonian learning systems' fixed, orderly, outcome-oriented, homeostatic regulatory and often passive teaching and learning encounters, to modifiable, developmental, creative, motivational and continuous systems. These Einsteinian education systems offer differentiated psychology of potential-based teaching and learning. In differential psychology, metacognition and SDL evolved concurrently in two separate channels.

To demonstrate metacognition's cognitive and emotional architecture of SDL, this chapter provides a theoretical framework, or map, rooted in metacognition's history and philosophy. Hudlicka (2005, p. 55) defines 'architecture' as cognitive mechanisms that 'support the exploration of affective-metacognitive interactions'. John Flavell describes metacognition as 'knowledge and cognition about cognitive phenomena' in his pioneering book *Metacognition and cognitive monitoring – a new field of cognitive-development investigation* (Flavell 1979, p. 906). Malcolm Knowles stated that 'self-directed learning is more in tune with our natural processes of psychological development' (Knowles 1975, p. 14). Metacognition and SDL are mediated by their cognitive-affective structures, according to this chapter.

Chapter 1 makes an original contribution to the field by exploring the epistemology of metacognition and SDL through historical and philosophical lenses. It examines the 'architecture' of mental processes, emphasising the structured organisation required for effective metacognition and SDL. By integrating cognitive and affective domains, the chapter highlights the importance of fostering higher-order thinking skills essential for real-world problem-solving. It underscores the foundational work of John Flavell and Malcolm Knowles, advocating for the development of metacognitive skills among educators to create supportive and engaging learning environments. These environments are crucial for nurturing self-directed learners capable of independent goal-setting and outcome evaluation. The chapter calls for further educational research into the interplay of cognitive and affective factors, aiming to enhance both academic success and emotional well-being in learners.

Chapter 2 focuses on the Thinking Hats teaching strategy and its potential benefits to advance metacognitive SDL. This chapter presents the findings of a qualitative phenomenological study conducted with a diverse group of pre-service teachers at a South African university. The study included participants from different subject fields, ranging from first- to fourth-year students, who willingly participated in the research. The sample size consisted of 450 participants. These participants were exposed to targeted training as part of their professional development, specifically focusing on four classroom-based teaching strategies. The aim of this training was to foster the development of metacognitive SDL skills. The project included pre-service teachers in assuming responsibility for their own learning and taking the initiative to make changes to their teaching practices, with the goal of becoming competent self-directed adult learners. This chapter delves into the written reflections of pre-service teachers about their experiences with professional development training. Specifically, it focuses on their assessments of the possible advantages of the project in developing metacognitive self-regulated learning. The results of the study indicate that the use of the Six Thinking Hats method has advantages in developing a range of thinking abilities and attitudes among prospective teachers. This approach enhances their awareness of metacognition and, to some degree, their ability to regulate metacognitive processes by using problem-solving techniques to facilitate SDL.

The chapter contributes significantly to the understanding and application of metacognitive SDL strategies in teacher education. By focusing on the Six Thinking Hats strategy, this chapter highlights the potential benefits of this teaching method in enhancing pre-service teachers' metacognitive awareness and regulation. The qualitative phenomenological study, involving 450 pre-service teachers, reveals that the Six Thinking Hats strategy facilitates the development of critical and creative thinking skills, promotes independent and cooperative learning, and encourages flexible and adaptive thinking. These findings suggest that incorporating such metacognitive strategies in teacher training programmes can prepare future educators to foster SDL among their students, ultimately contributing to the cultivation of life-long learning skills in a rapidly evolving educational landscape.

Chapter 3 focuses on mathematical noticing in pre-service teacher education and the affordances of metacognition. A learner-centred teaching-learning environment that emphasises mathematical proficiency requires teachers to recognise and interpret learner thinking and use learners' current understanding to make effective instructional decisions. Teachers may improve their awareness of particular teaching strategies

settings via mathematical noticing. Mathematical noticing involves ‘attending to learners’ strategies, interpreting their understandings, and deciding how to respond’ (Jacobs et al. 2012, p. 169). This chapter concentrates on mathematics noticing as reflection-on-action, when pre-service teachers re-evaluate, assess and plan how to enhance the learning experience or behave differently in the future. Results show that students grasp metacognitive knowledge and regulation while reflecting on their experience. They can explain what they learned, identify their skills and flaws, and aim to improve. This ability helps pupils become more self-directed and independent learners.

Mathematical noticing, where mathematics teachers attend to, interpret and decide how to respond to learners’ understanding of mathematics, has often been explored in the research literature. In this chapter, however, we argue that pre-service mathematics teachers should learn how to become mindful of their own experiences and thinking processes during and after problem-solving so that one day they may become metacognitively aware of their own teaching practices, modelling reflective thinking. The focus in this chapter, therefore, is on mathematical noticing as reflection-on-action, where pre-service teachers re-consider, evaluate and analyse the learning experience and devise an action plan on how to improve the learning experience or think how to act differently in the future. The chapter aims to investigate the affordances of reflection on pre-service teachers’ metacognitive knowledge and regulation. It furthermore aims to contribute to a deeper understanding of the role of reflection in promoting metacognition and mathematical noticing among pre-service teachers, providing valuable insights for improving pre-service teacher education programmes and preparing future mathematics teachers to effectively support student learning and mathematical development.

Chapter 4 pays attention to metacognitive reflection on a selection of history game genres to develop SDL. Game-based learning (GBL) is promising in many educational contexts, yet many instructors are unsure how to choose instructional video games. Which instructional video game selection approaches, standards, procedures and criteria work best? Genre, play style, medium, difficulty, goal(s), etc. are almost endless. The study’s main goal is to assess how video games affect GBL and SDL in third-year BEd students. Students’ video game choosing opinions were examined for SDL characteristics. Online interviews with 10 History for Education majors from a South African institution may help us build global GBL selection and implementation guidelines. This chapter introduces ideas and theories on self-direction in higher education and how GBL might encourage SDL and metacognition. After that, the chapter’s conceptual framework is deconstructed in relation to SDL, GBL and video games. The next section

covers the role of video games in SDL and metacognition, SDL, autonomy and choice in video games, feedback and reflection, problem-solving and critical thinking, the metacognitive cycle, reflection and strategy development, and the transfer of metacognitive skills. Situated Learning, Cognitive Apprenticeship, Flow Theory and Constructivist Learning were the theoretical framework. A description then follows of the hybrid video or interview technique utilised to collect data on participant perceptions, motivating reasons, difficulty and educational value of GBL selection for higher education. Results provide a strong basis for a practical applied framework for such a context.

This study contributes significantly to the fields of SDL and metacognition research by illustrating the dynamic role of GBL in fostering these critical educational competencies. By examining how third-year Bachelor of Education students interact with various history-themed video games, this research provides insights into how games can be selected and implemented to enhance SDL and metacognitive processes. The study demonstrates that video games can serve as effective tools for engaging students in self-directed, immersive learning experiences, promoting autonomy, reflective thinking and strategic planning. Furthermore, the findings underscore the importance of integrating theoretical frameworks such as Situated Learning, Cognitive Apprenticeship, Flow Theory and Constructivist Learning to develop a comprehensive approach to GBL. This holistic model not only addresses the limitations of traditional teaching methods but also highlights the potential of video games to create engaging, student-centred learning environments that support metacognitive development and self-regulation. Through its qualitative analysis and development of practical standards for GBL, this study provides a valuable foundation for future research and educational practice, aiming to enhance the efficacy of SDL and metacognition in higher education contexts.

Chapter 5 investigates modelling metacognitive monitoring skills and self-regulated learning by exploring teacher experiences in selected secondary schools. KwaZulu-Natal (KZN) in South Africa has a diverse cultural and contextual environment that affects students' learning and academic performance in schools across an educational transition. KZN has struggled to improve education despite its motto, *masisukume sakhe* ('let us rise and build'). This chapter suggests that enhancing metacognitive and self-regulated learning abilities might cut failure rates, provide students with 21st-century skills and prepare them for post-secondary jobs and personal achievement. Self-regulated learners can manage their emotions, conduct and cognition under challenging circumstances. This chapter explores teachers' confidence and teaching strategies to model and build metacognitive monitoring as a self-regulated learning competence in students. Zimmerman and Moylan's (2009) model of self-regulated learning

was used to reveal how secondary school teachers model metacognitive monitoring to teach metacognitive learning. This qualitative research used interpretivism to frame a basic interpretative qualitative study. Sixteen secondary school teachers were chosen for their knowledge of metacognitive monitoring and student learning. This study used content analysis and theme analysis to find cohesive meaning and improve understanding of the research goals. The research found that most participants believed they had the pedagogical content knowledge to develop metacognitive monitoring as a self-regulated learning capacity. The results also suggest that teachers require professional development to master learner-centred teaching methods to promote metacognitive and self-regulated learning skills.

This chapter provides valuable insights into the factors influencing teachers' confidence and capabilities in fostering metacognitive and self-regulated learning skills among students. It highlights how continuous professional development, extensive teaching experience and manageable workloads can enhance teachers' confidence. The chapter also identifies barriers to confidence, such as high workloads, teacher-centred approaches, lack of professional development and contextual challenges like language barriers and administrative burdens. Addressing these issues can help improve teacher efficacy. The research underscores the detrimental effects of rote memorisation and the need for student-centred learning environments. It also emphasises the impact of inadequate resources and time constraints on teachers' ability to develop students' metacognitive skills, pointing to the need for systemic changes and better support structures within schools. By providing specific examples and linking them to theoretical frameworks, the chapter offers practical insights into the application of metacognitive development in education, highlighting the importance of reflective practices, preparation techniques and teacher modelling.

Chapter 6 explores how metacognition and motivation influence classroom environments to enhance successful learning in the subject of accounting. Learning involves cognitive and metacognitive abilities and procedures (Grosser 2007). Metacognitive, motivational and behavioural self-regulation helps successful students attain academic objectives (Schleifer & Dull 2009). Effective learners are more motivated and productive, says Walton (2010). Consider classroom effects and personal obligations during learning. Anxiety reduction may boost learning and encourage accountants (Borja 2003). The instructional design for evaluating accounting classroom metacognitive skills uses constructivism (Schunk 2004).

An explanatory mixed method was used to study South African FET accounting classrooms. After quantitative study, the researcher examined specific outcomes qualitatively. To describe the main findings, the qualitative phase investigated the quantitative phase's essential features. A large sample of accounting students and teachers was descriptively surveyed initially. In the second part of the qualitative phase, semi-structured individual interviews with students and instructors and accounting classroom observations were utilised to explore the learning environment and how motivation and metacognition affect learning. All accounting teachers and Grades 10, 11 and 12 learners from Gauteng's Vaal Triangle secondary schools were sampled. The quantitative section of this research used the explanatory design to survey accounting Grade 10, 11 and 12 students ( $n = 576$ ) and teachers ( $n = 12$ ) from nine secondary schools in Gauteng's Vaal Triangle area.

The empirical investigation revealed how accounting metacognition might help learning, and how teachers may enhance their methods and create motivating learning environments to assist all students develop metacognition and succeed. The quantitative data indicated that many teachers feel they allow students to take ownership of their learning by expecting them to solve problems and inspire their responses. The qualitative data revealed that teachers expect students to tackle difficult situations on their own and motivate them. Accounting students need good teachers to succeed. Because of good accounting teachers, students who prepared ahead, completed assignments and engaged in class did better (Darwin 2011).

This chapter contributes to our understanding of how learners and teachers view the influence of motivation in the accounting classroom for learners to develop metacognitive skills that also lead to more SDL strategies and the development of problem-solving skills needed. This chapter shows how metacognition and motivation influence the classroom conditions for learners to experience successful learning in the accounting classroom. It focuses on what skills accounting learners need to develop to support metacognition in the classroom environments to enhance successful learning in accounting. To develop these metacognitive skills in the classroom, this chapter emphasises what role the motivation of learners plays in successful learning in accounting. Empirical evidence is provided to support the importance of motivation where positive relationships and attitudes towards the subject of accounting are practised and which, in the end, will contribute to motivating learners to persist and succeed in accounting. The study also provided evidence that when accounting teachers focus on the development of metacognitive skills, more SDL could

take place, and better pass rates and academic performance might be possible in the subject of accounting.

Chapter 7 examines problem-centred mathematics learning in Grade 2, focusing on a case for metacognitive thinking for enhanced understanding. Ineffective Foundation Phase teaching practices that fail to support learning with comprehension are commonly blamed for South Africa's poor mathematics education. Problem-centred learning (PCL) enhances metacognitive thinking and arithmetic understanding. Thus, this chapter analyses how Grade 2 PCL might help metacognitive thinking for maths comprehension. A three-phase action research study gathered data from four Grade 2 teachers who reflectively designed and implemented PCL methods. Focus group conversations before and after each micro-cycle and an initial open-ended questionnaire were collected. To understand how PCL principles assist metacognitive thinking, the three action research phases' data were analysed and interpreted using a metacognitive lens. Teachers agree with the literature supporting PCL in mathematics to increase metacognition; however, the statistics reveal participants failed to implement PCL principles, restricting their pupils' metacognition. Significant factors were direct math teaching, limited PCL and pedagogical skills, and teacher attitudes towards collaborative problem-solving math education. Data-driven concepts should guide PCL mathematics education in foundational grades.

The findings highlight the potential challenges and benefits of adopting PCL, such as improving learners' problem-solving skills, fostering SDL and addressing the diverse needs of students in a real-world context. This chapter fills a critical gap in the literature on early mathematics education and offers practical guidelines for educators to enhance metacognitive thinking and meaningful learning in mathematics.

Chapter 8 looks at Grade 7 mathematics learners' metacognitive thinking in problem-based tasks. Mathematical problem-solving requires metacognition or conscious thinking about one's cognitive processes. Namibian Grade 7 students use metacognitive reasoning to solve maths problems. One cohort of 36 Grade 7 students participated in a qualitative study. Six students worked in groups throughout the class. The intervention included two problem-based maths problems, worksheets, reflection sheets and semi-structured interviews. MS Word and Excel were used to analyse data. Three themes emerged from the research. The qualitative results showed that metacognitive thinking is necessary for solving mathematical issues, and the learners learned significant abilities for the future. Findings showed that problem-based exercises in Grade 7 helped students learn mathematics and build critical thinking abilities for real-world challenges.

This chapter is relevant as it illustrates how metacognitive strategies and collaborative efforts can significantly enhance Grade 7 learners' abilities to solve real-world mathematical problems. PBL supports mutual collaboration, enhances learners' SDL abilities and enables critical thinking and a deeper understanding of mathematical concepts. This integrated approach provided for life-long and self-directed skill development is essential for their future academic and personal success in mathematics.

Chapter 9 seeks to investigate the development of students' algebraic thinking through mathematical language and metacognitive strategies. Thinking algebraically is crucial to arithmetic learning and problem-solving. Many educational stakeholders worldwide are concerned about students' algebraic thinking. This chapter explains how mathematical language and metacognition help students learn algebra. A social constructivist design-based research method was used in a multicultural, dual-medium school with 37 Grade 7 mathematics students. The first author watched them during mathematical activities and gave them a vocabulary exam on algebraic ideas and operations and a written algebraic exercise. The first author taught metacognitive skills in class. Based on vocabulary test scores, 14 individuals were selected for task-based interviews. Correct mathematical language and metacognitive tactics improved learners' algebraic reasoning. The first author created a metacognitive strategy wheel to help teachers educate students on how to apply them.

The algebraic thinking of learners is not only a global but also a South African concern in mathematics education. The correct use of mathematical language, as well as metacognitive strategies, plays an important role in the development of algebraic thinking and problem-solving skills. In this research study, the learners are equipped with metacognitive strategies to improve their algebraic thinking. This chapter contributes to establish practical guidelines for mathematics educators to help them with the development of learners' algebraic thinking using metacognitive strategies.

Chapter 10 proposes a model for analysing the relationship between metacognitive awareness and worldview as mediating constructs of SDL. This study examined how metacognitive awareness and in-service teacher worldviews affect SDL areas. A quantitative postpositivist methodology is used to experimentally investigate how metacognitive awareness and worldview promote SDL. A representative sample of 142 South African private school students was studied. The 'Worldview questionnaire', 'Metacognitive awareness assessment' and 'Self-directed learning readiness scale' were used to construct descriptive and inferential statistics. Based on calculations, structural equation modelling provides four models that match this study's assumptions. Model 1 demonstrates a continual interaction between metacognitive regulation (watching myself) and

metacognitive knowledge (what strategy do I need to do this task?) to encourage self-direction. Model 2 links the integrated worldview and the visible realm of SDL. Metacognitive information seems to be unique in SDL, according to Model 3. Model 4 shows that metacognitive knowledge and integrated worldview promote SDL.

This chapter contributes significantly to the field of SDL by proposing and empirically validating a model that elucidates the intricate relationship between metacognitive awareness and worldview, mediated by SDL domains. By employing structural equation modelling, the chapter provides a robust analytical framework demonstrating how metacognitive knowledge and regulation interplay to foster SDL among in-service teachers. The study underscores the essential role of metacognitive awareness in enhancing teachers' capacity for SDL, emphasising that teachers' worldviews significantly influence their teaching practices and learning approaches. Furthermore, the chapter highlights the transformative potential of integrating metacognitive awareness with an integrated worldview to create more adaptable, reflective and self-directed educators. This contribution is pivotal in addressing the gaps in literature on the dynamic interaction between worldview and metacognitive processes in promoting effective SDL, thereby offering valuable insights for educational practice and policy.

# Metacognition: The cognitive and affective architecture of self-directed learning

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## ■ Abstract

Both metacognition and self-directed learning (SDL) research have reached a pivotal moment in 21st-century teaching and learning. As an educational necessity, the notion of an underlying principle of learning to discover and support sometimes unique learning needs, goals and processes calls for the exploration of the increasing number of research available on the topic. This chapter explores the epistemology of metacognition and SDL, drawing on historical and philosophical perspectives. The term 'architecture' refers to the structured organisation of mental processes, where metacognition involves the ability to think about, monitor and evaluate these processes. Cognitive and affective domains are crucial for fostering higher-order thinking skills, essential for developing motivated, creative individuals capable of solving real-world problems. Negative emotions such as anxiety and low confidence can hinder learning engagement and academic success. The work of John Flavell, introducing metacognition, and Malcolm Knowles,

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emphasising SDL, laid the foundation for understanding these concepts. Knowles defined SDL as a process where individuals independently identify learning needs, set goals and evaluate outcomes. This chapter argues that educators must develop metacognitive skills to create engaging and supportive learning environments. Such environments foster meaningful learning opportunities and positive affective experiences, encouraging students to become self-directed learners. The chapter underscores the need for educational research to further investigate the interplay of cognitive and affective factors in learning.

## ■ Orientation

This chapter offers a theoretical framework, or map, immersed in the history and philosophy of metacognition and self-directed learning (SDL) research to showcase how metacognition serves as a cognitive and affective architecture of SDL. The term ‘architecture’ is borrowed here from the work of Hudlicka (2005, p. 55) on cognitive structures to ‘support the exploration of affective-metacognitive interactions’. In the history and development of metacognition, the publication of John Flavell’s pioneering work, ‘Metacognition and cognitive monitoring – a new area of cognitive-development inquiry’, introduces metacognition as ‘knowledge and cognition about cognitive phenomena’ (Flavell 1979, p. 911). In the same period, pioneer Malcolm Knowles highlighted ‘that self-directed learning is more in tune with our natural processes of psychological development’ (Knowles 1975, p. 14). The argument made in this chapter is that the two theoretical strands, namely, metacognition and SDL, are mediated by their underpinning cognitive-affective architectures.

Architecture in psychology refers to the intelligent structure and organisation of mental processes. Metacognition is the capacity to think about, monitor and evaluate these processes. Cognitive architecture and the affective domain have gained interest from educational researchers, particularly with a focus on the role of higher-order thinking skills.

The foundation of education is the idea that learners and students will grow into individuals who are motivated, creative and capable of addressing problems in the real world. Negative learning experiences can creep into the learning environment when the learning experience incorporates signs of dread, anxiety or low confidence. Such unfavourable learning experiences have an impact on both learning engagement and the knowledge and comprehension necessary for academic success (Schoenfeld 2013, p. 9). According to this concept of learning, future educators must learn to demonstrate the metacognitive abilities required to encourage engagement with the learning process. To meet this need, we need a developed and

educated culture of self-directed teachers who prioritise meaningful learning opportunities, where the principles of teaching are pleasant affective experiences and the confident use of metacognitive skills. Such meta-affective experiences are still a rare subject in educational research, perhaps because of their theoretical and philosophical overtones or because of their psychological language (Efklides 2011, p. 6). Facilitators plan for and demonstrate suitable metacognitive abilities to promote learning and inspire confidence in learning when they aim to create SDL environments and experiences. Students may lose motivation and worry about upcoming learning chances when classroom surroundings do not allow them to guide their learning intrinsically.

## ■ Introduction

A 21st-century educational paradigm that would prepare students for the needs of society, academia and vocations for the 21st century is imminent (Bellanca 2010). Kayashima and Inaba (2003, p. 253) assert that the fundamental themes for 21st-century learning include 'mathematics, communication as collaboration through literacy, flexibility and adaptability, initiative and self-direction, social and cultural skills, creativity, critical thinking, and problem-solving'. Wagner (2012, p. 153) urges all institutions to consider the importance of scaffolding 21st-century skills in the curriculum. According to Kayashima and Inaba (2003, p. 253), a lack of these skills will lead to people being forced into low-paying, low-skilled jobs, a shortage of competent engineers and physicians, and a general downturn in a nation's economy. For more than 10 years, the media (Rademeyer 2009) and national periodicals have emphasised this (Siyepu 2013, p. 7). It seems that in order to protect both their own lives and the nation's economic competitiveness in the future, students need to learn how to adapt to a changing environment. Those who struggle to articulate their metacognitive thought processes must thus learn to externalise these internal processes by connecting their ideas to past information and experiences (Hurme, Palonen & Järvelä 2006, p. 181; Wilson 2001, p. 5).

The philosophical analysis conducted, and the framework proposed in this chapter attempt to understand how these experiences could foster a positive perspective on the cognitive and affective-metacognitive architecture in SDL environments. The constructs of affect, meta-affect and metacognition were contextualised in and by the conceptual framework of SDL experiences. In the theoretical framework, Brinck and Liljenfors' (2013, p. 85) account for three kinds of metacognition, namely, implicit, perceptual and meta-representational, assisted in structuring the architecture to understand how a perspective in learning develops during the SDL experience. The development of a metacognitive, cognitive and

affective architecture in the SDL environment might support meta-representations as a view on learning. This chapter introduces the epistemological foundations of metacognition for SDL and discusses practical and theoretical implications.

## ■ Self-directed learning

The enhancement of SDL serves as the overarching aim of 21st-century teaching. The International Society for Self-Directed Learning (ISSDL)'s board of directors adopted the following definition for SDL: 'self-directed learning is an intentional learning process that is created and evaluated by the learner' (ISSDL 2024). This definition is derived from the basis of Knowles's original position towards the definition: Metacognition and SDL are closely intertwined concepts, both being crucial for 21st-century education. Awareness and regulation of one's cognitive processes allow students to monitor and evaluate their thinking (Ghosh 2024, p. 3). This capability is essential in SDL, where individuals take charge of their learning journey. Having such a structured organisation of mental processes – the 'architecture' of metacognition – helps students navigate and optimise their cognitive and affective domains. Reflection on the engagement with a learning task fosters higher-order thinking skills, enabling students to solve real-world problems creatively and effectively (Wu, Sari & Huang 2024, p. 16).

Self-directed learning, as emphasised by Knowles (1975), involves individuals identifying their learning needs, setting goals and evaluating outcomes independently. There is some degree of terminological confusion regarding the essence of the term 'self-directed learning' (Van der Walt 2019, p. 1). An overview of the literature offers diverse conceptualisations, including seeing SDL as a concept (Knowles 1975), a term (Van der Walt 2019), a theoretical construct (Elbanna, Eid & Kamel 2015, p. 106), a theory (Niemer & Ryan 2009, p. 134), a model (Garrison 1997), an assumption of learning (Havenga 2016, p. 83) or a process (Morrison & Seaton 2014, p. 3).

Fundamentally, SDL is connected to metacognition, as it requires learners to reflect on their cognitive processes and strategies. In its essential form, SDL consists of several key ideas involving self-assessment, goal setting, strategic planning, choice of methods and resources, self-monitoring and self-reflection towards evaluating the effectiveness of their strategies and outcomes. To promote SDL, students' metacognitive skills need to be cultivated (Pokhrel & Sharma 2024, p. 4) and a learning environment should be created that caters for meaningful learning opportunities and positive affective experiences. This chapter argues for further research into the cognitive and affective factors influencing learning,

aiming to develop pedagogical strategies that encourage students to become motivated, self-directed learners.

## ■ A history of metacognition

An earlier and basic conceptualisation of metacognition simply describes the term as 'thinking about thinking' (Flavell 1979, p. 19). Metacognition has since then developed into a complex construct with an extensive history anchored in the development of cognition. The term refers to the capacity to plan, monitor and evaluate one's mental processes, resulting in increased self-awareness and improved methods of learning (Olszowski 2024, p. 122). Its historical development crosses epistemological borders such as philosophy, psychology and education.

In psychology, the idea of metacognition became more popular in the 20th century. A ground-breaking theory of cognitive development, put forward by Swiss developmental scientist Jean Piaget, emphasised children's progressive acquisition of metacognitive abilities. Piaget's research focused on the phases that children go through as they advance in their cognitive capacities and learn to reflect on their own ideas and behaviours (Lasaiba & Lasaiba 2024, p. 73). Concurrently, research by Lev Vygotsky made a substantial contribution to our knowledge of metacognition. According to Vygotsky's sociocultural theory, cultural and social interactions impact cognitive development (Bernard 2024, p. 70). He highlighted the role that social guidance and scaffolding play in helping people improve their metacognitive skills.

Flavell further advanced the field's understanding of the Flavell construct and distinguished between metacognitive regulation and metacognitive knowledge, which is the understanding of how one's mind functions (the control and management of cognitive processes). Metacognition research also benefited from advancements in neuroscience and technology. Technological developments in brain imaging have illuminated the underlying neurological mechanics of metacognitive processes by providing insights into their neural correlates. Metacognition's significance in education became increasingly recognised, leading to the development of strategies to enhance learning by focusing on metacognitive skills. Educators began incorporating metacognitive techniques into teaching methodologies, encouraging students to reflect on their thinking processes, set goals and monitor their own learning strategies. Today, research on metacognition continues to thrive across various fields, including psychology, neuroscience, education and artificial intelligence. The integration of metacognitive principles in artificial intelligence and machine learning aims to create more adaptive and self-aware systems.

When people alter the strategies they apply during learning, it is evident that reflective thinking and reasoning are being fostered. The first is related to the nature of the event, while the second is related to reflecting on one's own thoughts throughout the experience. This awareness of the choices made and how they affect future options (Hacker, Dunclosky & Graesser 2009; Proust 2013) is known as metacognitive awareness (Flavell 1979, p. 906). These metacognitive processes include an understanding and regulation of one's own thought processes, or self-regulation, and encompass thinking about abilities, strategies and emotions (Efklides 2011, p. 6). Therefore, metacognitive awareness arises when cognition is managed and controlled (e.g. knowledge of feelings and learning strategies) (Legg & Locker 2009, p. 347).

The idea of metacognition as a model of cognitive and affective monitoring was first introduced by Flavell (1979, p. 906). Initially, monitoring implies a reflection of one's own awareness or metacognitive knowledge of the cognitive processes (i.e. beliefs about the person, task and strategy) during the learning process. Later, Brown (1987, p. 65) introduced the managing and controlling of these processes as metacognitive regulation. Considering this, Zimmerman (2000) also identified self-regulation as a higher-order function that regulates metacognitive monitoring. There remains, however, discourse about the position of these higher-order cognitive monitoring processes whereby SDL is the cause or effect of metacognitive knowledge, metacognitive experience, metacognitive awareness and self-regulation, and their relationship with the affective domain. This includes effects such as motivation and confidence during the learning process.

It seems that there is still a lack of consensus and clarity on the true meaning of metacognition, despite the existence of well-written definitions that attempt to shed light on this nebulous term (Murphy 2012, p. 15). The lack of study on metacognition, especially in relation to its connection to SDL experiences, appears to be impeding the field's advancement and comprehension. According to Hurme et al. (2006, p. 181), for instance, metacognition stems from an individual's understanding and awareness of their own cognition and regulation, which is in line with Flavell (1979, p. 906).

Michalsky, Mevarech and Haibi (2009, p. 363) recognise metacognition's importance in peer questioning, whereas Schoenfeld (1992, p. 9) argues that metacognition is linked to SDL. Metacognition is described as a complicated and multidimensional notion by Barzilai and Zohar (2014, p. 13).

According to Waters and Schneider (2010), these definitions imply that knowledge, skills and communication influence metacognitive experiences

as varied categories and that the literature's definition of metacognition is still ambiguous. Proust (2013, p. 13) provides an unbiased explanation, though: 'Metacognition is the set of capacities through which an operating cognitive subsystem is evaluated or represented by another subsystem in a context-sensitive way'.

For the purpose of developing a theoretical framework on the cognitive and affective architecture of metacognition, Proust's (2013) definition is adequate as it differentiates between two cognitive levels. The operational aspect of metacognition - referred to as metacognitive and affective regulatory experiences by Brown (1987) and Efklides (2009) - is the first level. The second level describes metacognition as a representation of personal knowledge - or lack thereof - prior to, during and following an activity. Collectively, the works of Waters and Schneider (2010), Lai (2011, p. 40) and Hacker, Dunclosky and Graesser (1998) show that metacognition is a kind of knowledge and behaviour that arises from education, experience and learning.

## ■ The philosophy of metacognition

Philosophically, metacognition dives into fundamental enquiries about the nature of the self, consciousness, knowledge acquisition and the interplay between the mind and the external world. It sheds light on the intricacies of human cognition, perception and the mechanisms by which individuals become aware of, regulate and control their own thinking processes. Based on the definitions above, metacognition can be seen as a broader form of collective cognitive theory about the comparative psychology of cognitive processes (Jankowski & Holas 2014, p. 64) whereby metacognition refers to the theory about the higher-order cognitive processes, which regulate the networks of the cognitive processes.

One theoretical issue that has been dominating network and metacognition theories is the notion of a theoretical divide between these different forms of theories. Take for example social network analysis as a type of network theory and metacognition as a type of metacognition theory - they are two separate forms of theory, yet both types share the assumption that learning takes place in social settings (Coburn, Mata & Choi 2013, p. 311). The conceptual crisis exists when similar theories and concepts (e.g. theory of mind, self-regulated learning and cultural metacognition) fail to consider the social-networking character of metacognition and only acknowledge the self versus social character. This often leads to a limited view of the definition put forward by Flavell (1979, p. 906). At least part of this crisis may have practical implications when facilitating metacognition in one's teaching practice and explains, perhaps, why some studies show that teachers' metacognition is inadequate

(Jagals & Van der Walt 2016, p. 154). Part of the cause for this conceptual confusion lies in the way in which metacognition is expressed, observed and documented. The expressions of thoughts are, no doubt, an indication of how well learning has taken place and how thinking about thinking occurs. The complexity and looseness of metacognition's definition (Flavell 1979, p. 906) do not only question its conceptual nature but also question how the language of expressing this thinking is formulated and conveyed, as well as how this language facilitates the construction of new self-knowledge and other knowledge in metacognitive-social network contexts. At the same time, the field of metacognition developed from Flavell's 1975 publication, and Knowles's (1975) notion of SDL pioneered further research, particularly in the field of andragogy.

## ■ Metacognition as a higher-order cognitive function

De la Fuente et al. (2015) assert that automated procedures and conscious processes work best together. When students read a book, they must speak the language in which it is written fluently in order to comprehend the text when reading it to determine what needs to be done for the work. This reading serves as an example of automatised thought. Driving an automobile may also be thought of as an automated operation. To differentiate between pertinent and irrelevant information, students must analyse, make connections between concepts and consciously look for patterns. This is when metacognition becomes a higher-order cognitive function that is a conscious, intentional and reflective process. Based on the research by Pasquali, Timmermans and Cleeremans (2010, p. 182), reflections on affective and metacognitive experiences can occur when a student's declarative, procedural and conditional knowledge is associated with person, task and strategies that are already established.

## ■ Metacognition and nonconsciousness

A mental image or concept is created when the controlling function guides the information obtained through reflection. Nelson and Narens (1994, p. 12) refer to this reflective process as the link between metacognitive regulation and knowledge. A meta-reflection is formed by these two layers. The cognitive information that is obtained through reflection may be expressed through a sequence of shorter, decision-making or reflective questioning. These reflections can take the form of symbols or icons with syntactical or semantic representations. Therefore, the phrase 'metacognitive thinking' refers to a metacognitive vocabulary indicating the *verb* that is strongly related to the 'metacognitive knowledge domain'

and that can be articulated in terms of ‘person, task, and strategy knowledge’ (Whorf et al. 2012). Examples of these expressions include the following: I think we can do this..., I feel this is the best solution and I wonder if this would work. In addition to creating mental representations because of reflection, conscious, automatic and nonconscious metacognitive thinking also seems to produce an awareness of regulating the metacognitive knowledge (Hacker et al. 1998).

## ■ Metacognition and self-regulated learning

Self-regulation was the term used by Flavell (1979) and Brown (1987, p. 65) to describe the process of cognitive managing of thinking. Self-regulated learning involves a more comprehensive approach to managing thinking that encompasses goal setting, planning, employing strategies, monitoring progress and managing motivation across the entire learning process. Metacognition is a part of the broader framework of self-regulated learning, specifically addressing one’s thinking, while self-regulated learning covers a wider range of behaviours and strategies involved in managing one’s learning.

The following scenarios illustrate the difference between metacognition and self-regulation:

On the one hand, students may notice that they are struggling to comprehend certain sections when they read. They pause and reflect on their understanding. They realise that employing a specific strategy, like breaking down complex sentences or looking up unfamiliar terms, could enhance comprehension. They actively monitor their comprehension as they read, adjusting their strategy when needed. They become aware and gain knowledge of their thinking processes, and this is metacognition.

On the other hand, the students might plan their study schedule by setting specific goals for each study session. Before starting, they evaluate their current understanding of the material by taking a practice quiz. While studying, they use various strategies like summarising content, creating flashcards and teaching the material to themselves. As they study, they monitor their progress, adjusting the pace or strategies based on how well they retain information. Additionally, they manage their motivation by taking breaks, rewarding themselves after completing sections and staying focused on the ultimate goal of mastering the content.

## □ The concept of metacognitive regulation

According to Smith et al. (2009, p. 7), past knowledge is related to students’ capacity to actively monitor and control their thought processes.

This implies that a crucial component of the metacognitive thinking process is the knowledge about the individual, the task and the methods that are in line with the declarative, procedural and conditional knowledge domains. On the contrary, people's performance may decrease if they are unaware that they lack the required information (Wilson & Clarke 2004, p. 25). Metacognitive awareness, according to Lai (2011, p. 21), gives pupils the ability to control their cognitive processes, which encourages self-directed and lifelong learning.

This empowerment calls for preparation, observation and assessment (Atwater, Russell & Butler 2013). Self-control techniques depend on the limits of the learning material, as well as an understanding of one's own limitations and knowing how they affect the metacognitive experiences that promote lifelong learning (Efklides 2011). Furthermore, these knowledge processes are described by Akyol and Garrison (2011, p. 183) as cognitive and emotional functions of monitoring and control to fortify new information and methods.

Additionally, Akyol and Garrison (2011, p. 185) examined how these metacognitive elements originate from chat rooms and online forums, asserting that these kinds of communities exchange and require metacognitive knowledge in order to keep an eye on and control one's own as well as other people's cognitive processes. Self-knowledge becomes co-regulated and shared in terms of this shared metacognition. Ertmer and Newby (1996, p. 43) presented self-regulation as metacognitive regulation as this word is more frequently used in the literature, despite the fact that Flavell and Brown's work is ground-breaking in the field of metacognition research (Hacker et al. 1998; Proust 2013; Waters & Schneider 2010).

Ader (2013) investigated these regulatory processes using a framework for metacognitive questioning and prompting, concluding that self-talk and feedback are important for metacognitive regulation. Furthermore, Chua, Morris and Mor (2012, p. 116) recognised cultural metacognition as an important facet of metacognitive knowledge and regulatory domains, where language (Proust 2013) is linked to metacognitive thinking as it places the metacognitive experiences in context (Akyol & Garrison 2011, p. 183).

## □ Planning

Hurme et al. (2006) observed undergraduate students using metacognitive strategies and concluded that individuals engaged in metacognitive activity did not take planning into account. Rather than using this approach, students with problem-solving skills worked in groups and posed questions to clarify their ideas and address opposing viewpoints. Even if they may

not plan consciously, they can create meaning and share their ideas when they actively participate in such networked learning settings. Planning, according to Barzilai and Zohar (2014, p. 13), comprises goal setting, strategy selection, prediction, strategy organisation and resource sharing, posing questions such as: Did I look at other theories?

When Veenmen, Van Hout-Wolters and Afflerbach (2006, p. 27) state, 'Either you are capable of planning your actions ahead and task performance advances smoothly, or you don't and your actions go awry', they are making a crucial statement about planning. Thus, it would appear that one cannot plan without controlling and reflecting upon metacognitive knowledge. Veenmen et al. (2006) state that self-instructions, which are a part of planning, are typically ignored unless they are stated clearly. Veenmen et al.'s (2006) argument, however, suggests that this type of metacognitive language also has an internal, self-talking and self-instructive relationship with the metacognitive regulatory domain.

Murata and Ohta (2013) also argued that ineffective learning is caused by a lack of preparation, which is consistent with keeping track of the process and having a thorough comprehension of the work at hand. Moos (2014, p. 128) adduces that, in terms of performance monitoring, planning is linked to the emotional cognitive domain and metacognitive experiences. This appears to be consistent with the findings of Proust (2013) and Flavell (1979, p. 907), which state that students who plan to learn and collaborate while doing so will keep track of their past, present and future actions.

## □ Monitoring

A shift in how one plans and approaches a learning task necessitates keeping an eye on and managing one's cognitive processes (Markova & Legerstee 2013, p. 105). Monitoring, according to Lai (2011, p. 40), is related to planning and assessing, and it involves paying attention to comprehension (Schraw & Moshman 1995, p. 351) and the awareness of task performance. Monitoring engages memory and practice during reflection and synchronises the cognitive processes, claim Akyol and Garrison (2011, p. 183).

Making the student aware of his or her willingness to modify and control methods and techniques during learning has an impact on the cognitive state. According to Ader (2013), monitoring entails recognising trends and appraising errors as a conscious and purposive experience. As a result, monitoring allows one to assess the validity of conditional knowledge during planning and evaluate the declarative and procedural knowledge. Students may keep an eye on both their own knowledge and their classmates' knowledge in collaborative learning settings. In order to monitor and communicate metacognitively about their thinking, students

might pose questions while expressing their own thoughts and others' thoughts (Barzilai & Zohar 2014, p. 14). As they exchange metacognition and pick up new techniques, the group members may then modify their ideas and approaches as they foster interpersonal and intergroup relationships (Chua et al. 2012; Yzerbyt & Demoulin 2011, p. 243).

Students who are able to monitor metacognitive experiences are more equipped to explain both their own thinking and other people's thinking. They can also reflect, debate and assess how these experiences are planned and carried out.

## □ Evaluation

Evaluation is defined as an examination of the effort, result and learning process and involves reflection on and modification of task goals (Lai 2011, p. 35; Schraw & Mosham 1995, p. 351). The assessment process might then involve considering the success of the strategies employed and the plans specified in order to become aware of the differences between the objective and the metacognitive knowledge (Moos 2014). Hurme et al.'s (2006) example demonstrates how this might encourage critical thought and metacognitive questions. Hurme et al. (2006, p. 187) provided an evaluation example in a discussion, saying, 'We revised the example, so it should now be correct. Could you please have someone look it over? However, it modifies itself automatically. Why?... Reflect!'

Metacognitive evaluations in a problem-based learning setting were investigated by McMahon and Luca (2007). They concluded that students assessed their performance with the intention of improving it only when they were aware of the standards for doing so (by providing a rubric for the course objectives). It is also possible to assess the requirement for more resources, which raises awareness of what is and is not understood. This understanding encouraged students to ask questions and inspired them to consider what they had learned during the planning and monitoring stages in order to modify their strategy and planning and get better results. According to Akyol and Garrison (2011), assessment enhances one's capacity for critical thought and concept interpretation. According to Martinez (2006), appraisal needs to occur on both social and personal levels.

This suggests that in order to interpret one's own consciousness, reflection first takes place on a personal level. Afterwards, reflection happens on a social level in order to communicate and share one's own knowledge with peers. When members of the group work together in this way, they may build a network and use each other's feedback to improve task performance by talking about metacognitive thinking and forming connections. It also provides a verbal expression of the participants' metacognitive thinking (Hurme et al. 2006).

## □ **The relationship between metacognition and self-directed learning**

Self-directed learning, in its most general sense, can be defined as the experience of trying to achieve a goal with an awareness of the steps and resources involved. When SDL experiences are demotivating, negative and anxiety provoking, the individual's perspective of learning will, likely, be a discouraging one. Negative perspectives can discourage further interest and study opportunities involving future engagement with similar learning tasks. When experiences are motivating, positive and encouraging, a habit of applying higher-order (metacognitive) thinking skills develops and promotes confidence.

In addition, Efklides (2011) suggests that learning environments are sources of motivational power and explain that experiences contextualise the affective and metacognitive impacts on personal attributes (i.e. intentions, beliefs and attitudes). Modelling metacognitive skills such as reflecting, planning and monitoring can result in such metacognitive experiences and can foster an awareness of the affective experiences (e.g. feelings of anxiety or confidence). When reflected upon, on a deeper level, awareness of the metacognitive experience renders meta-affect, that is, thinking about the feeling of knowing (Efklides 2011). Affect, metacognition and meta-affect, therefore, are considered interrelated complex constructs that underpin the development of an individual's SDL experience. As metacognitive abilities are necessary for successful SDL, there is an association between metacognition and SDL. The following instances demonstrate this relationship.

### □ ***Goal setting***

When learning on their own, students may establish clear objectives. In doing so, metacognition is essential because it enables them to evaluate their current understanding, pinpoint knowledge gaps and establish reasonable, attainable objectives. For example, when learning a new language, a student may utilise metacognitive skills to choose which areas, such as vocabulary, grammar or conversational abilities, they should concentrate on.

### □ ***Selecting learning strategies***

Self-directed learners have the autonomy to choose the teaching strategies that best suit their needs. They employ metacognition to ascertain which strategies are most effective for them. For example, a student might reflect on past experiences and realise that creating mind maps or using flashcards enhances their understanding better than simply reading textbooks.

### ☐ **Monitoring progress**

They may monitor themselves and modify their learning strategies in light of their comprehension thanks to metacognition.

### ☐ **Self-regulating learning**

Metacognition may be used to regulate learning. Self-directed learners who apply metacognitive strategies may effectively manage their time, prioritise their tasks and alter course as needed. When studying a musical instrument, for example, a student may be aware of when they are having trouble with a certain technique and take proactive steps to get further help or direction in order to get better.

### ☐ **Reflecting on learning**

Metacognition enables reflection, which is a crucial aspect of SDL. Using metacognitive skills, students may reflect on what they have learned, how they have learned it and any areas where more research may be required. For example, a professional taking an online course might reflect on how certain concepts relate to their work and how they can apply newfound knowledge in their job.

Metacognition provides the foundation for SDL by empowering individuals to plan, monitor, regulate and reflect on their learning process autonomously. It allows students to take charge of their learning journey, adapt their strategies and achieve their learning goals effectively.

## ■ **Affect and metacognition in self-directed learning**

Affect is regarded as an extraordinarily influential internal representation of the deep and vulnerable emotional engagement. Individuals represent this with their cognitive systems, including the system of experiences related to SDL (Debellis & Goldin 2006, p. 131). The feelings experienced in learning situations can relate to metacognitive experiences (Efklides 2009). In the metacognitive knowledge domain, Flavell (1979) explains cognition about cognition, and affect involves the attitudes and beliefs related to learning (Efklides 2011). Through perceiving the level of difficulty of a task, emotions are triggered, which, in turn, necessitate control in order to experience (or feel) success or confidence (Tornare, Czajkowski & Pons 2015). This means that metacognition represents the knowledge, skills and feelings about oneself and contributes to the elucidation of the self-concept in directing one's learning experiences. Taken together, affect and metacognition contribute to the formation of SDL experiences.

Research on affect and SDL shows that under-confidence can lead to feelings of anxiousness (Efklides 2009), frustration and anger (Tornare et al. 2015), which could lead to task avoidance as a defence mechanism. On the contrary, positive affective experiences involve feelings of relief, excitement, pleasure, satisfaction and joy as a result of strategic metacognitive thinking (Debellis & Golding 2006), which fosters a positive perspective on learning. This is confirmed by Proust (2007), claiming that beliefs and attitudes are in relation with the intention of learning. Proust (2007) also explains that a person has a developing capacity to monitor the state of thinking. When metacognition is regarded as 'thinking about thinking' (Flavell 1979), it can be argued that thinking about feeling creates a different and more affective awareness of the self. This conceptual overlap between affect and metacognition, Efklides (2011) explains, can be referred to as meta-affect.

## □ Meta-affect

Meta-affect, according to Debellis and Goldin (2006), is emotion related to and contained inside cognition. Meta-affect conceptually ranks higher in the hierarchy of affect and metacognition as it captures our capacity for coping with affective situations.

According to the above argument, reflection takes place on two levels: firstly, personally, to interpret one's own consciousness; and secondly, socially, to communicate and share one's own knowledge with others. By working together in this way, group members may build a network and strengthen relationships between them by exchanging ideas on metacognitive thinking. This allows for the use of feedback from others to improve task performance. It also verbally conveys the participants' metacognitive thoughts (Hurme et al. 2006).

A reciprocal link exists between affect and metacognition. Emotions affect metacognition – the process by which we think about how we think, and metacognitive skills can affect how we perceive, comprehend and control our emotions. Comprehending this overlap is essential to understanding how emotions may either support or interfere with our ability to think clearly and regulate ourselves. The learner can feel meta-affect because of this overlap between affect and metacognition, as learning experiences shape the affect or emotions associated with the material. Such meta-affective experiences seem to develop when the individual thinks about the direction of their feelings (Debellis & Goldin 2006).

To explain this link between affect and metacognition, consider students studying for an exam and feeling confident and motivated. In this positive emotional state, they might actively assess their understanding of the

material (metacognitive monitoring). Feeling confident, they might believe they understand the concepts well, leading them to feel assured about their preparation. Their positive emotions could enhance their ability to employ effective study strategies. They might engage in active learning techniques, self-testing and elaborate encoding because of their increased motivation (affect).

However, imagine another scenario where the same students start feeling anxious or stressed as the exam approaches. Their anxiety might lead to increased monitoring of their comprehension, but it might also make them doubt their abilities. They might start second-guessing themselves, thinking they don't understand the material well enough. Because of anxiety, their ability to employ effective study strategies might be hindered. They might struggle to focus, experience racing thoughts or find it challenging to concentrate on studying effectively.

In both scenarios, emotions like confidence or anxiety influence how this person monitors their understanding and regulates their study strategies – the two essential aspects of metacognition. This shows how emotional states can impact metacognitive processes, affecting study habits, self-assessment and overall preparation for the exam.

## ■ Towards a metacognitive architecture of self-directed learning

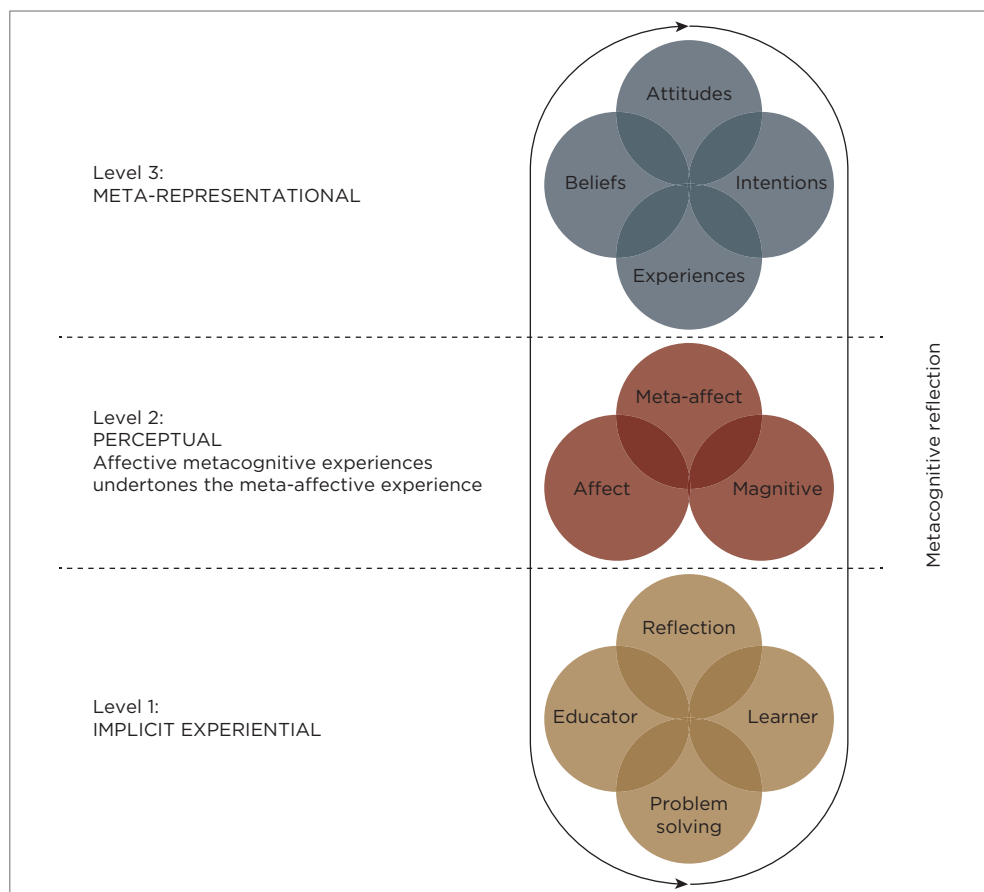
Understanding the nature of these relationships and theorising about meta-representations, in line with Rorty (1995) and Heyns (2006), require a strong perspectivist view based on an epistemology of engagement. An epistemology of engagement theory explains that objects are represented in the mind by rebuilding images of these objects from foundational ideas connected to the objects (Heyns 2006), thereby shaping the individual's perspective. Tying affective, metacognitive and meta-affective experiences (as the objects in this case) to the 'implicit, perceptual and meta-representational levels' of Brinck and Liljenfors's (2013) theoretical framework of metacognition, the awareness of these experiences develops into perspectives on SDL experiences. This argument is in line with Schlogman (2005) who explains that feeling and thinking are inseparably combined and dissimilar in nature, and they form part of the complex hierarchical structure of one's perspective. Therefore, the perspective that a student holds exists because of the mental representations formed about the experiences with learning, even though the perspective may not be an exact representation of the experience.

Experiences with SDL are, in view of the above, complex phenomena; we have yet to understand how the affective, metacognitive and meta-affective

experiences arise as a consequence of the hierarchical structure of reflection on learning and how the nature of the relationship promotes a positive learning perspective.

The intention of this chapter was to provide a framework that explains the cognitive and affective architecture of SDL. To do so, the literature was reviewed to offer an understanding of the nature of the relationship between affective, metacognitive and meta-affective experiences to theorise about how the relationship promotes meta-representations as a positive learning perspective in SDL environments. Figure 1.1 presents a model framework, or theoretical map, to showcase the flow of metacognitive reflection on three levels.

Self-directed learning experiences are implicit in nature and, when reflected upon, create awareness of the affective, metacognitive and



Source: Author's own creation.

**FIGURE 1.1:** Flow of metacognitive reflection to promote self-directed learning experiences.

meta-affective experiences on a perceptual level. Perceived awareness of the nature of the affective, metacognitive and meta-affective experiences then shapes the beliefs, intentions, experiences and attitudes which promote the student's perspective as a mental representation of the experience.

Experiences with SDL indicate students' and lecturer's reflections that revolve around self and other awareness. Learners' skilfulness in approaching learning (on the perceptual level) and their reflections on SDL experiences are founded in their perceptual experiences about their affect, metacognition and meta-affect (Little & McDaniel 2015).

When an individual's knowledge and affect are in line with and meet their perceived needs for SDL, metacognitive thinking takes place. By doing this, it is possible that the students will be able to pinpoint the aspects of the experience that they believe can assist them in shifting from negative affect (I feel like I didn't practice and I get frustrated easily) to positive affect (I am good at something and I get excited when I actively work on things like that). This is particularly true for children who are able to relate to concepts that they find pertinent, helpful and meaningful (e.g. I like these ideas).

Positive or negative experiences can still lead to attitudes, beliefs and experiences that influence how students solve mathematical problems in the future or view the subject in general. For example, a student may believe that a particular task is challenging if they feel isolated from other students. This connects the apparent emotive experience with the general attitude developed towards learning. According to Proust (2007), attitudes towards experiences create a meta-representation that the person uses to assess their beliefs, forecast how those beliefs will be experienced and create an internal mental picture of the event. Future experiences with SDL can therefore be guided, informed and justified by these meta-representations, also known as views on SDL.

Proust (2007) views meta-representations as a third or higher form of metacognition. This higher form involves awareness of the attitudes, intentions, experiences and beliefs regarding learning. Courneya, Pratt and Collins (2008) explain that these four elements develop an individual's perspective of learning. Intentions manifest as products of metacognitive thinking when the individual predicts outcomes and sets goals. The experiences that these affective and metacognitive elements foster shape the perspective the individual holds. The attitudes and beliefs that rise from reflection on the learning experience and form part of the affective experiences are perceived notions of affect and metacognition. Perceptual metacognition, therefore, consists of the awareness of affective, metacognitive and meta-affective experiences.

Implicit and perceptual metacognition serve as the underpinning framework of how an individual perceives experiences. How an individual sees experiences is underpinned by implicit and perceptive metacognition. Schlogman (2005) argues that affective experiences form an individual's perspective and control both action and thought. The perspective through reflection informs future affective and metacognitive experiences by creating awareness of the implicit, perceptual metacognition as a meta-representation. Meta-representation of the implicit and perceptual metacognition, therefore, suggests that experiences (on the implicit level) create awareness of the affective, metacognitive and meta-affective experiences (on the perceptual level), which, collectively, direct and justify the perspective formed about the experience as a meta-representation.

## ■ Conclusion

Self-directed learning encourages introspection and critical thinking. In turn, thinking back on the process of learning raises awareness of implicit and perceptual experiences, and it is connected to affect, metacognition and meta-affect. By recalling the ideas, intents and attitudes of the experience, thinking about the consciousness of these experiences fosters meta-representations or mental images of the experience. Therefore, pleasant experiences with SDL might arise when implicit and perceptual reflections evoke concepts and emotions related to liking, composure, calmness, confidence and an overall favourable outlook on learning. Focus and awareness are necessary to shift the affective state of learning, and these qualities result in self-directed, independent, critical and confident thinking, all of which support a positive outlook.



# The Thinking Hats teaching strategy: Potential benefits to advance metacognitive self-directed learning

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## ■ Abstract

This chapter reports on the findings of a qualitative phenomenological study with a heterogeneous group of willing first- to fourth-year pre-service teachers from a South African University ( $n = 450$ ). The participants were representative of different subject fields and received purposeful exposure to training as part of professional development in four classroom-based teaching strategies to encourage the development of metacognitive self-directed learning (SDL). The project engaged pre-service teachers as self-responsible and self-directed initiators of change to their teaching practices to become effective self-directed adult students. Furthermore, the chapter explores the pre-service teachers' written reflections about their experiences with the professional development training and, in particular for this chapter, their perceptions about the project's potential benefits for advancing metacognitive self-regulated learning. The findings revealed that exposure to the Six Thinking Hats strategy holds benefits for equipping pre-teachers with a variety of thinking skills and dispositions to advance metacognitive awareness and, to a limited extent, metacognitive regulation through problem-solving to self-direct learning.

## ■ Introduction

The changing and challenging world of the 21st century, in conjunction with the emergence of the fourth and fifth industrial revolutions, necessitates adjustments to education systems (Arpaci 2018, p. 82; Cansoy 2018, p. 3113) to enable students<sup>1</sup> to benefit from and cope with proceeding transformations in the world they live (Schwab 2016, p. 9). These transformations comprise continuous and exponential specialised knowledge growth (Karataş & Arpaci 2021, p. 2), the permeating power of digitalisation and information technology, innovations in the biological realm (Schwab 2016, p. 24) and the closer multi-level cooperation between humans and machines (Noack 2023). It is indispensable to not only teach knowledge at school level but also foreground the cultivation of thinking skills, particularly well-developed dispositions and attitudes that would enhance the ability to engage in metacognitive self-directed learning (SDL) (Bailey 2016, pp. 1, 5; Cansoy 2018, p. 3113; Coberley-Holt & Elufiede 2019, p. 21; Kamp 2016, p. 19; Karataş & Arpaci 2021, pp. 2-3) that is essential to advance lifelong learning in a changing and challenging world.

Consequently, teacher training institutions need to embrace the urgency to reform pedagogical approaches to teaching and learning,

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1. In this chapter, the authors make use of the term 'students' to collectively refer to individuals at school level and tertiary level.

specifically relating to cognitive development strategies (Boser 2017, p. 6; Fashant et al. 2020, p. xiv; Haiyan, Walker & Xiaowei 2017, p. 101; Harrington 2018; Van Wyk 2017, p. 274). This being said, prospective teachers need to acquire a series of skills and competencies (Cooper, Farah & Mrstik 2020, p. 125) comprising, among others, computer literacy, digital learning (Bozkurt & Sharma 2020; Kim 2020, p. 149; Şentürk 2021, p. 38), SDL skills, and metacognitive awareness and metacognitive regulation skills (Bozkurt & Sharma 2020, p. 1; Hadar et al. 2020, p. 573; Quigley 2018, p. 10). Possessing these skills would empower teachers to cultivate these skills and competencies among the students whom they will teach. In particular, Taşkin and Tüzün (2015, p. 55) argue that it is essential to gain skills related to learning how to learn as well as how to organise the learning process. In this respect, the concepts of metacognition and SDL instantaneously surface. Metacognition and SDL encapsulate the need to reflect independently about the management of one's own learning process, autonomously determining learning goals, becoming self-reliant in organising learning and accessing resources to support learning, as well as taking the initiative to learn in a self-directed and controlled manner (Du Toit-Brits & Van Zyl 2017, pp. 123, 125). Metacognition comprises metacognitive awareness and metacognitive regulation, which both play a fundamental role in encouraging and strengthening self-regulated and, eventually, SDL (Karataş 2017, p. 451; Quigley 2018, p. 9).

## ■ Problem statement

The problem that the authors wish to accentuate is three-fold in nature. Firstly, the improvement of thinking skills and dispositions that are prerequisites for competent SDL has been an ideal of South African education since 1997 (Department of Education 1997, p. 3, 2002, pp. 10, 12, 2011, p. 4; Du Toit-Brits & Van Zyl 2017, p. 125). However, nationally, Booysse (2016) and, internationally, Harrington (2018) and Kazachikhina (2019, p. 292) express their concern that teachers pay little attention in school classrooms to equipping students explicitly to become self-directed as certain preconceptions, such as SDL being for adult learners only, may lead to this lack of attention. Recent research has also shown that metacognitive skills, skills that enable them to progressively become more self-directed, are either below average or moderate (Liu et al. 2017, p. 3249; Wei et al. 2019, p. 67; Ye et al. 2018, p. 2418).

Therefore, the need for pre-service teachers to become knowledgeable about how to encourage students to become intentional critical thinkers about their learning (metacognition) is crucial for impacting future teaching practices at school level that aim to advance SDL (Barnett 2015, p. 64;

Bowell 2017, p. 584; Erikson & Erikson 2018, p. 2294; Fashant et al. 2020, p. 229; Grosser & Olivier 2017, pp. 31, 32; Gupta & Singh 2022, p. 331).

Secondly, teacher-centred teaching and learning approaches with limited emphasis on the development of SDL compound the limited emphasis on the development of SDL (Girvan, Conneely & Tangney 2016, p. 130; Lotz 2016; Toh & Kirschner 2020). Teacher-centred teaching and learning approaches no longer serve the roles students will have to play in the 21st century. According to Brandt (2020, p. 3), to survive in the workforce of the 21st century, school leavers must possess the ability to assume responsibility for their own learning. This entails the capacity to strategise, cultivate, modify and adjust their learning approach in a digitally advanced, interactive and globally interconnected society. For this reason, teachers need to expose students at school to teaching and learning strategies that encourage cognitive and metacognitive involvement during teaching learning in favour of passive teaching (Tekkol & Demirel 2018, p. 11; Toh & Kirschner 2020).

Thirdly, a lack of understanding among teachers on how to advance the development of self-directedness obstructs its development. The lack of understanding possibly arises from educational beliefs and programmes that prioritise content-area knowledge and pedagogical approaches that favour product-oriented over process-oriented learning, development and motivation (Bolhuis & Voeten 2002, pp. 837-839; Geduld 2019, p. 61). Pre-service teachers, therefore, ought to become knowledgeable about teaching and learning approaches that would effectively transform school students from dependent to self-directed (Herlo 2017, p. 7; Kazachikhina 2019, p. 292; Toh & Kirschner 2020; Voskamp, Kuiper & Volman 2022, p. 772). Teachers need to become role models for metacognitive SDL that would leave a long-lasting impression on their students (Noklang 2020, p. 218). However, if teacher training does not equip pre-service teachers with the necessary teaching strategies to become role models for SDL (Mahawiro 2018, p. 77), the preparation of students at school level to cope with challenges in a continuously changing world might be unsuccessful.

To address the three-folded problem, the authors propose the purposeful accentuation of embedding teaching strategies into teacher-training curricula that could further metacognitive self-directed involvement during teaching and learning. One such strategy the authors wish to suggest is the Thinking Hats strategy, which cultivates autonomous and independent thinking (De Bono 1985, p. 31). Therefore, the research reported in this chapter aims to answer the following research question: To what extent would the Thinking Hats teaching strategy advance the development of metacognitive SDL among pre-service teachers? To ascertain the efficacy of this intervention and the extent to which the students' metacognitive

SDL has evolved, the researchers employed a group assignment activity that the students completed for formal assessment purposes during the training and written reflections on their experiences with the professional development training. For the purpose of this chapter, metacognitive SDL refers to the presence of reflective (metacognition) and independent and autonomous (self-directed) cognitive engagement during learning.

## ■ Theoretical framework

Self-directed learning is based on the principles of adult learning theory (Knowles 1975a, p. 15), which proposes that students should identify their own learning needs, take responsibility for and take charge of their learning process and skills development (Louws et al. 2017, p. 171; O'Neill 2020). These are all vital for students at higher education institutions. According to this theory, students should be engaged in learning material that has real-world relevance and practical application (Manning 2007, p. 105). In this regard, the constructivist theory that advocates for greater independent and autonomous learning appeared relevant to this study's research.

According to Muhajirah (2020, p. 39), the fundamental principle of constructivist teaching and learning theory is the need for learning to allow students to construct and scaffold knowledge rather than passively receive knowledge. This occurs when the teacher also implements activities that allow for the scaffolding of knowledge. Piaget (1973) and Vygotsky (1978) developed the most prominent viewpoints and ideas about constructivism. According to Shabani, Khatib and Ebadi (2010, p. 241), the cognitive-constructivist view of Piaget proposes that students act as active constructors and discoverers of knowledge. Vygotsky's approach to constructivist theory explains that more skilled peers or adults should guide learning activities (Rogoff 1999, p. 72), thus supporting a social-constructivist approach to learning where the focus is on social interaction in learning and development. According to cognitive constructivism, knowledge construction relies on cognitive processes within an individual (Orak 2021, p. 167), as opposed to a social-constructivist approach where knowledge is constructed through interaction with others (Powell & Kalina 2009). It could be concluded that cognitive constructivism is an individualistic perspective regarding knowledge acquisition and construction. Students are encouraged by their teachers to think critically and to learn independently (Amineh & Asl 2015, p. 10; Rahmayanti & Nirwana 2021, p. 416).

Working within the Zone of Proximal Development (ZPD) (Vygotsky 1978, p. 86) model also plays a vital role in constructivist learning. Vygotsky (1978, p. 86) conceptualised the ZPD as the discrepancy

between the current level of development achieved through independent problem-solving and the potential level of development attainable through problem-solving with the guidance of an adult or collaboration with a more proficient peer. The training and support received by the pre-service teachers during the professional development training enabled them to work within the ZPD by applying the Six Thinking Hats strategy and becoming more self-directed during learning. A cognitive-constructivist and socio-constructivist perspective also underpinned professional training to advance independent and social interaction during learning. The study's findings were interpreted through the lenses of cognitive and social constructivism theories. These theories offered a detailed framework for analysis, enabling a deeper understanding of how participants learned. Piaget's cognitive-constructivist perspective helped explain how participants independently built their knowledge and developed SDL abilities.

Conversely, Vygotsky's social constructivism emphasises the importance of social interactions, peer collaboration and scaffolding in promoting learning within the ZPD. Combining these perspectives, the study examined the dynamic interaction between individual cognitive processes and social learning interactions. This dual-theoretical approach provided a richer, more comprehensive understanding of the learning experiences and outcomes, capturing both independent and collaborative aspects of knowledge construction. In conclusion, integrating cognitive and social constructivism offered a detailed and multifaceted analysis of the study's findings.

## ■ Literature review

### ■ Promoting self-directed learning within higher education

According to Kamp (2016, p. 21), the transition from a knowledge-centric community to a global learning-centric community will result in a reconceptualisation of the notion of success in education. Rather than emphasising knowledge acquisition, success will be determined by students' ability to independently recognise, recover, recall, manipulate, understand and utilise new knowledge. In this respect, it seems reasonable to argue that teachers must become well-informed about cultivating SDL in their classrooms.

According to Cosnefroy and Carré (2014, p. 3) and Loeng (2013, p. 241), SDL can be described as a six-step process involving '(1) developing goals for study, (2) outlining assessment concerning how the students will know

when they achieve those goals, (3) identifying the structure and sequence of activities, (4) laying out a timeline to complete activities, (5) identifying resources to achieve each goal and (6) locating a mentor/faculty member to provide feedback on the plan’.

In a nutshell, SDL refers to a pedagogical approach wherein students assume responsibility for diagnosing their own learning requirements, formulating learning objectives, identifying learning resources, choosing and implementing learning strategies, and assessing the outcomes of their learning endeavours (Knowles 1975b). One could argue that the definition reveals that the application of core critical thinking skills such as analysis, evaluation, synthesis (creative thinking), making inferences and deductions, providing explanations, making interpretations and self-regulation (independently planning, monitoring and evaluating learning) lie at the core of SDL (Bailey 2016, p. 78; Coberley-Holt & Elufiede 2019, p. 22; Uribe-Enciso, Uribe-Enciso & Vargas-Daza 2017, pp. 80, 81). Thus, well-developed critical thinking skills will pave the way for students to become independent, self-regulated, reflective and engaged during learning. Obied and Gad (2017, p. 68) contend that strong independence, curiosity and self-confidence in one’s own abilities to organise and plan learning tasks to solve problems contribute to becoming more self-directed during learning. Critical thinking skills assist students in developing deeper metacognitive and higher-order thinking and processing skills required to apply and synthesise knowledge (Mahoney, Patterson & Hall 2022, p. 5):

Moreover, the development of dispositions, such as perseverance, curiosity, inquisitiveness, empathy, integrity, humility, fairness, open-mindedness, [flexible thinking,] a questioning attitude, and systematic working ways need to be [encouraged,] as they are viewed as [essential] characteristics of a self-directed student. (Costa 2009; Guglielmino 2013; Obied & Gad 2017, p. 68; Van Tonder, Kloppers & Grosser 2022)

Problem-based learning (PBL) and problem-solving are valuable teaching strategies for nurturing the development of critical thinking skills central to SDL (Choi, Lindquist & Song 2014, p. 53; Guglielmino 2013, p. 5). Problem-solving frequently encourages students to articulate and re-articulate learning goals, purposes and learning needs, thus purposefully engaging students in self-directing a problem-solving activity. Problem-solving also promotes applying critical thinking skills, such as analysis and interpretation, that form the basis of SDL (Paul & Elder 2006). Group work or cooperative learning that presents opportunities for social interaction during learning enables students to learn how to, among others, engage in autonomous self-directed cognitive processing of information that promotes learning engagement and encourages the development of self-confidence in one’s independent efforts (Booyesen et al. 2017).

Students engaging in SDL are expected to take significant ownership of their learning beyond what is mandated by an outside source (such as a teacher or a set of course requirements) (Van der Walt 2019, p. 1), freeing the teacher to focus on facilitating the learning process (Loeng 2013, p. 241). Self-directed learning represents a radical change for teachers, who are now expected to take on roles such as facilitator of learning, motivator, designer of the learning situation and, frequently, co-learner with their students as they acquire new pedagogical expertise (such as facilitation) and subject matter expertise (such as context beyond their expertise) (Loeng 2018, p. 4). This means that SDL gives students agency for their own education and makes them feel like they are learning something meaningful. Therefore, Dehnad et al. (2014, p. 5184) concur that a well-planned SDL setting not only boosts students' motivation but also boosts their sense of agency, self-assurance and self-belief. In particular, it encourages our students to think outside the box and expand their horizons of what they may study.

Self-regulation processes, which lie at the core of becoming self-directed and taking responsibility to learn (Bailey 2016; Coberley-Holt & Elufiede 2019; Uribe-Enciso et al. 2017), are elucidated below.

## ■ The relationship between self-regulated learning and self-directed learning

Cosnefroy and Carré (2014, p. 2) purport that in the context of SDL, students independently define and direct learning, which is characteristic of good self-regulation and self-determination ability. However, self-regulated learning (SRL) relies on teacher-generated tasks and externally controlled learning. Self-regulated learning encompasses a continuum ranging from limited self-regulation, characterised by external teacher control, to elevated self-regulation, characterised by increased student autonomy and decision-making throughout the learning process (Goetz, Nett & Hall 2013, p. 123). Self-directed learning and SRL both regulate cognitive processes during the learning process (Saks & Leijen 2014, p. 190). However, SDL specifically emphasises independent and autonomous decision-making by the student, while SRL encompasses a blend of decisions made by the teacher and those initiated by the student. One could, therefore, argue that high levels of self-regulation would enable a student to become more self-directed.

During didactic teaching, more self-paced tasks should be introduced early on to assist pre-service teachers in becoming more self-regulated in their 'self-directedness' (Makonye 2016, p. 23). Scaffolding might help pre-service teachers become better at self-regulation. Examples of scaffolding

involve students in managing some of the key components that play a role during learning: (1) beginning with tasks that they can do at their own speed and getting them used to setting their own goals and deadlines (Arsic 2014, p. 13); (2) independent engagement in critical thinking and problem-solving (Kellenberg, Schmidt & Werner 2017, p. 25; Schunk & Greene 2017); (3) exposure to opportunities to engage in reflection and thinking about one's understanding and possible adaptations to the learning process, learning environment and learning strategies (Escorcía & Gimenes 2020); and (4) reflecting on, and regulating the desire and motivation to learn and achieve learning goals (Palfreyman & Benson 2019).

## ■ The role of metacognition in advancing self-directed learning

Metacognition plays a vital role in becoming self-regulated and, ultimately, self-directed (Karataş 2017, p. 451; Quigley 2018, p. 9). Flavell (1979) first introduced the notion of metacognition as the comprehension and consciousness of cognitive mechanisms to control behaviour. Scholars such as Alexander, Carr and Schwanenflugel (1995, p. 2); Hacker (1998, p. 3); Jaleel and Premachandran (2016, p. 165); Kills and Yıldırım (2018, p. 56); and Veenman et al. (2006, p. 5) employed phrases such as 'thinking about thinking' or 'higher-order cognition of cognition' to explicate this notion. Involvement in metacognitive actions encourages students to take ownership of responsiveness to learn and become self-directed (Karataş 2017, p.451; Marra, Hacker & Plumb 2022, p. 138; Sandhu & Zarabi 2018, p. 76).

Flavell (1979) states that metacognition is a kind of reflective thinking in which a person becomes aware of, monitors, receives feedback on, and modifies various cognitive elements influencing one's own state of mind, task goals and learning techniques. According to Maduabuchi, Ogbonnaya and Angela (2016, p. 75) and Ramadhanti and Yanda (2021, p. 202), engaging students in acquiring and applying metacognitive skills assists them in arranging their learning, fostering SDL and enhancing their task performance.

Metacognitive involvement during learning promotes students' critical thinking, decision-making skills, general self-efficacy and professional values (Arslan 2015, p. 2; Chen, Bi & Zhang 2018, p. 3749; Chen et al. 2019, p. 15; Safari & Meskini 2015, p. 152). Metacognition may be considered the internal roadmap students follow while engaging in any given learning activity or task (Muijs & Bokhove 2020, p. 6). Subsequently, metacognition comes into play by checking in or organising cognitive control on the progress and results of the learning efforts (Jin & Ji 2021, p. 936).

Metacognition is the awareness of one's own cognitive processes and methods or strategies for controlling these cognitive processes during learning (Mahdavi 2014, p. 529).

Aligned with the discussion above, Hacker, Keener and Kircher (2009, p. 154) distinguish between two features of metacognition, namely, *metacognitive awareness* and *metacognitive regulation*, which guided the execution of the research reported in this chapter.

## ■ Metacognitive awareness

According to Helms-Lorenz and Jacobse (2008), engaging in metacognitive awareness or metacognitive knowledge (Muijs & Bokhove 2020, p. 6) enables individuals to effectively strategise, organise and evaluate their own learning processes, leading to observable enhancements in their overall performance. The significance of metacognitive awareness within the context of education and academic pursuits is noteworthy. Hacker et al. (2009, p. 154) identified four fundamental criteria for metacognitive awareness. Metacognitive awareness emphasises the following: (1) one's knowledge about the factors that could influence learning and performance; (2) one's knowledge about suitable strategies to boost learning, which refers to information about a student's learning process or strategies and techniques for maximising performance on a given task (Jin & Ji 2021, p. 938; Karably & Zarbrucky 2009, p. 35; Muijs & Bokhove 2020, p. 7); (3) knowledge about strategies to augment one's ability to control and manage one's mental processes; and (4) being able to identify one's own level of competence in a subject or the most effective ways to learn in a specific subject area (Pressley & Harris 2006, p. 265). Niedringhaus (2010, p. 113) asserts that students who possess metacognitive awareness are characterised by their ability to comprehend and regulate their own learning processes.

In the authors' view, metacognitive awareness implies self-assessment. To this end, Asy'ari and Ikhsan (2019, p. 457) assert that self-assessment includes cognitive regulation or metacognitive awareness to manage thought processes and learning activities. Furthermore, the process entails understanding the suitable timing for, approach to and justification for employing different learning strategies (Harrison & Vallin 2018, p. 16; Tuononen et al. 2023, p. 38). The aforementioned bears a remarkable resemblance to the ability of students to engage in introspection concerning their own learning. This characteristic is associated with students' academic ability at the university level (Tuononen, Parpala & Lindblom-Ylänne 2017). According to Abdelrahman (2020, p. 5), various studies have suggested a favourable association between elevated levels of metacognitive awareness abilities and academic performance.

Conversely, students who possess lower levels of metacognitive awareness skills exhibit inferior academic accomplishments (Koçak & Boyacı 2010, p. 772; Narang & Saini 2013, p. 170). Therefore, metacognitive awareness has the potential to function as a strong predictor of academic competence (Nbina & Viko 2010, p. 3; Rezvan, Ahmadi & Abedi 2006, p. 425). Additionally, numerous studies, such as those carried out by Coutinho (2007, p. 40), Koçak and Boyacı (2010, p. 772), Narang and Saini (2013, p. 172), Nietfeld, Cao and Osborne (2005, p. 23), Sperling et al. (2004, p. 121) and Young and Fry (2008, p. 1), have consistently revealed a robust affirmative association between metacognitive awareness, metacognitive self-regulation and improved academic achievement. This is achieved through the instructor's indirect instillation of these skills.

## ■ Metacognitive regulation

Metacognitive regulation, also referred to as metacognitive control (Muijs & Bokhove 2020, p. 6), pertains to the ability to influence one's cognitive processing, such as the adaptable utilisation of various processing activities, contingent upon situational factors and interim learning outcomes (Kallio, Virta & Kallio 2018, p. 98). Regulatory activities involve pre-planning prior to a given course or assignment and implementing monitoring and information management strategies during the learning task (Pintrich 2004; Vermunt & Verloop 1999, p. 258). According to Kallio et al. (2018, p. 98), metacognitive regulation refers to the strategies students employ to regulate and adjust the advancement of their cognitive processes. These procedures emerge as incidental outcomes within the framework of discipline-specific education, and corrective exercises can be regarded as their preliminary antecedents (Von Wright 1992, p. 60).

Metacognitive regulation encompasses a range of behavioural patterns utilised to coordinate and control deliberate attempts to learn and solve problems. Brown and DeLoache (1983) and Muijs and Bokhove (2020, p. 6) identified various patterns within metacognitive processes, which encompass predicting actions or events, monitoring ongoing activity, verifying the outcomes of actions and engaging in reality testing, among other related behaviours. According to Veenman, Wilhelm and Beishuizen (2004), there is a strong interdependence among cognitive regulation processes. Following the research findings of Veenman, Prins and Elshout (2002), the capacity to control cognitive processes can be delineated by qualities such as profound engagement, systematic organisation, precision, critical assessment and thorough development, which can be interpreted as proficiency indicators. Veenman et al. (2004) discovered that, to a certain extent, this type of proficiency is a universal, individual attribute that transcends age groups rather than being specific to a particular domain.

In sum, metacognitive regulation focuses on taking action to improve our learning processes and learning outcomes (Quigley 2018, p. 10). This involves (1) goal setting, (2) planning learning, (3) implementing the learning plan and monitoring learning progress and (4) evaluating the results of one's learning efforts. Additionally, metacognitive regulation also refers to knowing how to direct motivational and affective factors and control contextual and environmental conditions that could hamper learning success (Quigley 2018, pp. 9, 12). Motivational and affective factors include, among others, students having a firm grasp on how to control their own learning as well as the thoughts, emotions and beliefs they have towards themselves and others (Gonullu & Artar 2014, p. 226).

## ■ The Six Thinking Hats strategy

According to Medina, Castleberry and Persky (2017, p. 78), the development of metacognitive ability can be facilitated by using efficient teaching strategies and engaging learning activities. Students would benefit from metacognitive techniques during briefing, simulation and debriefing (Josephsen 2017, p. 675). Exam wrappers that direct students to review their performance and the teacher's feedback (Poorman & Mastorovich 2016, p. 283; Schuler & Chung 2019, p. 417; Williams 2019, p. 52) and PBL (Mohammadi et al. 2019, p. 1096; Yu et al. 2015, p. 99) are two other strategies that have been shown to dramatically increase students' metacognitive abilities and foster better study habits. Nurturing Habits of Mind (Costa 2009, p. 15) and employing Thinking Maps (Hyerle 2014, p. 161) and Cooperative Learning (Booyesen & Grosser 2014, p. 47) during teaching also support the development of independent, critical and confident students who are encouraged to self-direct the learning process.

Learning institutions play a crucial role in enhancing knowledge and skills through pedagogical guidance and practical application, as Veenman et al. (2006) noted. Instruction that advances metacognition should involve designing suitable learning experiences and settings to facilitate open-ended learning to achieve a harmonious equilibrium between student independence, ambiguity and motivation. (Kamp 2016, p. 48). To this end, the authors argue specifically for applying the Six Thinking Hats strategy.

De Bono (1985, p. 31) introduced the Six Thinking Hats strategy, which consists of six distinct modes of thinking: White Hat, Red Hat, Black Hat, Yellow Hat, Green Hat and Blue Hat. Each hat represents a different approach to thinking and problem-solving. According to De Bono (1992), the strategy allows individuals to focus on one mode of thinking at a time before transitioning to another. The thinking modes are associated with a specific colour hat, and teachers engage students in practising the application of the various thinking modes by altering the different coloured

hats during teaching (De Bono 1985, p. 31; Evans & Carolan 2014, p. 111). The Six Thinking Hats strategy has gained popularity in promoting critical thinking (Hightower 2019). Teachers utilise this strategy by assigning different coloured hats to students, engaging them in applying various thinking modes during learning (De Bono 1985, p. 31; Evans & Carolan 2014, pp. 112-113). Teachers must remember that the colours of the hats are not specific descriptors of the individuals wearing them but instead of their behaviours (Mahoney et al. 2022, p. 5). According to De Bono (1992), the colours of the hats symbolise various cognitive directions and processes.

The White Hat emphasises a neutral and objective approach, considering facts and information. The Red Hat encourages the expression of emotional views. The Black Hat deals with critical thinking and negative aspects. The Yellow Hat promotes optimism and positive thinking. The Green Hat focuses on creativity and generating new ideas. Lastly, the Blue Hat emphasises control, structure and the ability to synthesise (Evans & Carolan 2014, pp. 112-113).

Hammouda and Jarad (2020) and Labelle (2018, p. 90) concur that the Six Thinking Hats strategy involves intentional, goal-directed and metacognitive actions. Individuals are encouraged to reflect independently on the suitability of applying a specific thinking action represented by a particular hat about a specific learning task or challenge. Van Tonder et al. (2022, pp. 6, 7) argue that the Six Thinking Hats strategy encourages the flexible use of different thinking modes, such as factual, evaluative, critical, creative, synthesis and argumentative thinking. According to the authors, students become proficient in selecting appropriate thinking modes for different tasks and challenges, which advance metacognitive awareness.

The authors concur that the Six Thinking Hats strategy offers advantages such as fostering an environment that encourages the expression of ideas by peers without fear or the possibility of being exposed to ridicule. Students are encouraged to develop self-assurance in information exchange, collaboration and constructive dialogue. An additional advantage pertains to the recognition of diverse viewpoints during the dissemination of information.

Also, the Six Thinking Hats strategy promotes metacognitive self-regulation and encourages individuals to remain focused and aware of their thinking processes throughout the learning journey (Hightower 2019). The Six Thinking Hats strategy alerts one to be metacognitively aware of parallel thinking, full spectrum thinking and how to separate ego from thinking and become flexible, autonomous, self-directed and independent during thinking and learning (Hammouda & Jarad 2020, pp. 59, 60; Labelle 2018, p. 89). Another advantage of employing the Six Thinking Hat approach is promoting a supportive environment, encouraging individuals to express

their thoughts without apprehension of criticism or mockery. According to Mahoney et al. (2022, p. 5), these advantages enable students to develop a sense of self-assurance when engaging in the activities of sharing, collaborating and engaging in respectful discussions.

## ■ Methodology

### ■ Research design, strategy and data collection

The researchers employed qualitative phenomenological research to explore the pre-service teachers' written reflections about their experiences with the professional development training and, for the purpose of this chapter, their perceptions about the Six Thinking Hats strategy's potential benefits for advancing metacognitive SDL (Creswell & Plano Clark 2018). Also, a group assignment activity completed for formal assessment purposes during the training by the students was used for data collection.

Although three other teaching strategies, namely, Habits of Mind, Thinking Maps and Cooperative Learning, were also employed, and their potential benefits for encouraging metacognitive SDL were explored during the research, this chapter only focuses on the reflection data obtained for the Thinking Hats strategy.

### ■ Participant selection and intervention

Based on the positive findings of a pilot study that aimed to establish the advances of Thinking Hats for encouraging metacognitive self-regulation, the findings reported in this chapter extend the pilot study to a larger group of students ( $n = 450$ ). The authors made use of non-probability sampling and approached pre-service teachers who would be willing to become trained in a research project.

The one-year intervention comprised a theoretical component that involved four teaching strategies (two strategies per semester). A four-hour theory facilitation session per strategy followed a practical group assignment per strategy that expected students to apply the theory to solve a problem. The group assignments were submitted for formal assessment purposes.

### ■ Ethical considerations

This research was a low-risk study. Our research study has been meticulously vetted and approved by the North-West University's Faculty of Education Sciences Research Ethics Committee (EduREC) and the Research Data Gatekeepers Committee (RDGC). The EduREC, responsible for ensuring

the ethical standards of our research, approved our study under the number NWU-0128-20A2. The RDGC, tasked with safeguarding the integrity and privacy of our research data, also granted their approval under the number NWU-GK-2020-042. These approval numbers signify the thoroughness of our legal clearance process.

Respecting the autonomy of our participants and recognising the significance of their role, an independent person was entrusted to send a recruitment letter to the target population via the researchers' eFundi sites. This letter was an invitation for participants to voluntarily contribute to the study, underlining their pivotal role and the profound impact their participation would have on the research.

The confidentiality of our participants was of utmost importance to us. To ensure this, the researchers used pseudonyms to protect their identities. An informed consent form was developed for participants to sign before data gathering, a task undertaken by an independent person. Only participants who signed the informed consent voluntarily had their data considered for data analysis in this study, further reinforcing our commitment to their privacy.

The informed consent form, which was explained to each participant in detail, indicated how and why the participants were selected, the potential risks and benefits of the study, and their type of involvement. It also clearly stated that their participation in this study was voluntary and that anonymity and confidentiality were ensured. The form was designed to ensure that participants fully understood the study's purpose, their rights and the potential risks and benefits, thereby reinforcing the protection of participants' rights.

At the same time, the form ensured that the participants could withdraw from the study at any time and provided the project leader's contact details should questions arise.

## ■ Data analysis

Guided by the two focus points of the study that were deductively identified from the literature review, namely, *metacognitive awareness* and *metacognitive regulation*, a thematic analysis was employed to analyse the reflection data in relation to the two focus points. Inductively, interesting and additional themes and sub-themes that did not directly relate to the two focus points were also identified in the data. Emergent themes and sub-themes were identified within the data to allow the subjective meaning of the participants' answers to be reflected (Willig & Rogers 2017). ATLAS.ti™ was used to extract the themes and sub-themes by the third author. Initially, the coding was manually done and verified by using ATLAS.ti™ to

code the data again with ATLAS.ti™'s artificial intelligence assistant coder. The most meaningful responses to support the identified themes and sub-themes are presented as direct verbatim quotations from the raw data. For the responses, the participant number, year group and subject were utilised as identifiers.

## ■ Trustworthiness of the research

The researchers diligently adhered to the intended measurements to ensure the study's credibility. To accomplish this objective, preserving the original transcripts for verification was imperative. Additionally, verbatim descriptions and direct statements were employed to substantiate the auditable criterion (Shenton 2004, p. 64). Furthermore, the retention of the initial transcripts was deemed vital for verification. Mertler and Charles (2011, p. 199) assert that the study adhered to consistent research methodologies over an extended period to ensure dependability. To enhance the dependability of the study, the methods employed in the research were meticulously delineated, facilitating the replication of the study and instilling a sense of trust in the obtained research outcomes. According to Mertens (2010, p. 259), the concept of transferability entails the identification of similar situations that can serve as examples to demonstrate how data can be interpreted in various settings and from different perspectives. To address the transferability aspect of qualitative research, the researchers provided a comprehensive depiction of the findings, enabling them to ascertain how they can be used in similar contexts. The study's focus on specific individuals and places poses challenges in establishing the applicability of the results to broader populations and scenarios.

## ■ Results

Table 2.1 summarises the deductive and inductive four emerging themes and related sub-themes extracted from the data.

### ■ Theme 1: Metacognitive awareness: The development of skills to advance self-directed learning

Under Theme 1, sub-themes emerged which pointed to an increase in metacognitive awareness that was promoted when applying the Six Thinking Hats strategy. This increase in metacognitive awareness, in turn, led to the enhancement of SDL skills. The students reported improvements in their ability to analyse which enabled them to break down problems and

**TABLE 2.1:** Themes and sub-themes that emerged from the data.

Themes	Sub-themes
1. Metacognitive awareness: The development of skills to advance SDL	<ul style="list-style-type: none"> <li>• Analyses</li> <li>• Creative thinking</li> <li>• Critical thinking</li> </ul>
2. Metacognitive awareness: The development of dispositions to advance SDL	<ul style="list-style-type: none"> <li>• Multiple perspectives and viewpoints</li> <li>• Nurturing independence</li> <li>• Encouraging group work</li> <li>• Adjusting thinking</li> </ul>
3. Metacognitive regulation: Exposure to problem-solving activities	<ul style="list-style-type: none"> <li>• Improvement in problem-solving</li> </ul>
4. Positive attitudes towards the Thinking Hats strategy	<ul style="list-style-type: none"> <li>• Fun and uplifting</li> <li>• Improving understanding and gaining knowledge</li> </ul>

Source: Authors' own work.

Key: SDL, self-directed learning.

questions with greater efficacy. General improvements in creative and critical thinking were also noted.

### □ Sub-theme: Analyses

The students reported that the application of Thinking Hats enabled them to analyse problems and questions with greater efficacy:

'I have learned to break down the topics.' (Participant 148, 2nd Year, Economics)

'The thinking strategy thinking hats provide me with clear understand of how to answer the question given, it's also help me how to analyse the questions.' (Participant 32, 2nd Year, Business Studies)

'It's helpful because it helps breaks down questions and make them more easier to answer while answering the whole concept.' (Participant 9, 3rd Year, History)

'It helped me in being able to analyse a problem from different angles which also makes it easy to develop possible solutions.' (Participant 84, 4th Year, Business Studies)

### □ Sub-theme: Creative thinking

The students reported that using the Six Thinking Hats improved their general creative thinking:

'Thinking hats are effective and they help me to think creatively.' (Participant 23, 2nd Year, History)

'Thinking out of the box. Improves academic writing.' (Participant 72, 2nd Year, Economics)

'It allows it to structure studying not and thinking out of the box when answering questions.' (Participant 20, 3rd Year, History)

'For me this strategy should be mandatory in every class and every topic because it forces you to think outside the box and pushes you to be cooperative.' (Participant 27, 4th Year, Accounting)

## □ Sub-theme: Critical thinking

The students also made explicit remarks regarding the positive impact of the Six Thinking Hats, stating that it enhanced their critical thinking skills:

'It enables us to think critically and evaluate situations broadly.' (Participant 53, 1st Year, Accounting)

'My experience with thinking hats is a very good experience because I got a lot of information from them, and they allowed me to think critically.' (Participant 65, 2nd Year, Business Studies)

'It helps with creativity and enables critical thinking.' (Participant 8, 3rd Year, Business Studies)

'It makes to be a critical thinker.' (Participant 80, 4th Year, Business Studies)

The data above confirm that the students possibly became metacognitively aware of skills to assist them in arranging and engaging in their learning (Chen et al. 2018, pp. 37-49; Maduabuchi et al. 2016, p. 75) in a self-directed manner. It seems that the students acquired some of the core critical thinking skills that will be foundational in becoming independent and self-directed during learning (Obied & Gad 2017, p. 68).

## ■ Theme 2: Metacognitive awareness: The development of dispositions to advance self-directed learning

Under Theme 2, sub-themes emerged that indicated an increase in metacognitive awareness, which enhanced SDL dispositions. The students reported increased exposure to multiple perspectives and viewpoints, which led to increased overall comprehension and an inclination to incorporate said perspectives and viewpoints where needed. Furthermore, the Six Thinking Hats led to the student becoming more inclined to be independent in their own learning and working in groups. Lastly, the students were aware of the utility of the Six Thinking Hats for adjusting one's thinking.

## □ Sub-theme: Multiple perspectives and viewpoints

Students reported that the Six Thinking Hats facilitated exposure to new perspectives and viewpoints, which enabled greater comprehension of different perspectives and viewpoints. The students also seemed more inclined to incorporate diverse perspectives and viewpoints:

'I've learnt to also tackle situations from different perspectives.' (Participant 54, 1st Year, Accounting)

'The hats are instruments that help focus thought and consider alternative viewpoints.' (Participant 70, 2nd Year, Business Studies)

'It is effective as it helps one grasp different ideas and helps one understand loads of information simpler.' (Participant 12, 3rd Year, History)

'It helped me to know that we can look at a situation in different ways and perspectives to solve a problem faster.' (Participant 87, 4th Year, Business Studies)

### □ Sub-theme: Nurturing independence

The student noted increased independence when approaching learning and problem-solving:

'This strategy made me want to look into a problem when it comes to my learning rather than just give up because when I do not understand something.' (Participant 100, 1st Year, Accounting)

'It positively enhanced my learning strategies, and I can independently engage in self-directed learning.' (Participant 144, 2nd Year, Economics)

'It allows it to structure studying not and thinking out of the box when answering questions.' (Participant 20, 3rd Year, History)

'Equipping me with individual accountability and self-motivation skills.' (Participant 71, 4th Year, Business Studies)

### □ Sub-theme: Encouraging group work

The students noted that the Six Thinking Hats facilitated interaction and provided a platform for cooperative learning. Specifically, group work was frequently associated with implementing the Six Thinking Hats within the classroom context:

'I love it because it promotes cooperative learning.' (Participant 4th Year, Business Studies)

'I think thinking hats is an amazing strategy to solve a problem especially in an organisation or even in team or group schoolwork.' (Participant 26, 1st Year, Business Studies)

'I'll group learners into six, and each will choose each hate and do it.' (Participant 4, 3rd Year, History)

'By dividing learners in groups and each group focus on each hat.' (Participant 142, 2nd Year, Economics)

### □ Sub-theme: Adapting thinking

The students further reflected that the Six Thinking Hats can be applied to adjust an individual's thinking. This thinking adaptation was also associated with a teaching and learning strategy within a classroom context:

'When teaching a learning I would love to implement them in class both practically and theoretically. We will first learn the topic and then see how different learners respond, right after that I introduce the 6 Thinking Hats theoretically, practically

so, I will then write the 6 Thinking Hats into small paper, and each will have to pick one and then answer or ask questions on the content or case study given to him or her.' (Participant 97, 1st Year, Accounting)

'As a student who was learning about Thinking Hats I think Pupils can produce a lot of information and more specialised information by using the six hats. Pupils can be able to organise their thoughts and communicate them clearly thanks to the headgear. The hats are instruments that help focus thought and consider alternative viewpoints.' (Participant 70, 2nd Year, Business Studies)

'Give learners the most suited and a bit challenging questions to make them I am aware of their capabilities but also expand their thinking.' (Participant 16, 3rd Year, History)

'Everyone who has a different hat has something to do and the workload is not put on one or few member's shoulders, \*It encourages a more structured way of thinking. \*encourages students in a discussion to be more concentrated and attentive.' (Participant 56, 4th Year Business Studies)

Based on the data, the authors deduced that the Six Thinking Hats strategy possibly contributed to metacognitive awareness about dispositions that promote flexible and adaptive thinking (Guglielmino 2013) and increased independence during learning (Amineh & Asl 2015, p. 12; Rahmayanti & Nirwana 2021, p. 415), which are viewed as important characteristics of a self-directed student. Additionally, the observed evidence of interaction during learning testifies to learning engagement that could encourage self-confidence and independence (Booyesen et al. 2017) as attributes of a self-directed student.

### ■ **Theme 3: Metacognitive regulation: Exposure to problem-solving activities**

Under Theme 3, a sub-theme emerged which showed an increase in metacognitive regulation when problems needed to be solved.

#### □ **Sub-theme: Improvement in problem-solving**

The students highlighted that there was an improvement in their problem-solving that aligned more with the requirements of the task at hand:

'To evaluate problem and solve them.' (Participant 58, 1st Year, Accounting)

'The six thinking hats provides six different perspectives on the problem.' (Participant 46, 2nd Year, Business Studies)

'It will help me structure my own questions which might appear on the exams, this will somehow help me know what to expect and learn to how I should go about answering these questions.' (Participant 10, 3rd Year, History)

'It allows you as an individual to develop your thinking and problem-solving skills.' (Participant 84, 4th Year, Business Studies)

Problem-solving outside their education was also touted as an advantage of using Thinking Hats:

'I think thinking hats is an amazing strategy to solve a problem especially in an organisation or even in team or group schoolwork.' (Participant 100, 1st Year, Accounting)

'They do so by helping me to have different strategies on solving a problem.' (Participant 38, 2nd Year, Business Studies)

'Thinking hats helps me to solve more challenging economics problems.' (Participant 174, 2nd Year, Economics)

'I have learned that there are various ways problem can be solved.' (Participant 68, 4th, Year Business Studies)

The data likely support problem-solving, which is considered to contribute to increased SDL (Obied & Gad 2017, p. 72). Problem-solving holds the potential to encourage metacognitive regulation concerning formulating and reformulating learning goals, purposes and learning needs (Choi et al. 2014; Guglielmino 2013), thus promoting the regulation and adjustment of cognitive processes (Kallio et al. 2018, p. 98). Moreover, problem-solving encourages metacognitive reflection about learning goals, purposes and learning needs (Paul & Elder 2006) to consider improvements in actions that would improve learning processes (Quigley 2018).

A final theme provided interesting responses that were unrelated to the two focus points on which the research focused.

## ■ Theme 4: Positive attitudes towards the Thinking Hats strategy

Under Theme 4, sub-themes emerged, which pointed to a positive response in using the Six Thinking Hats. Students noted that when applying the Six Thinking Hats, the learning process is improved because of the increased enjoyment of the strategy. The general effect of the Six Thinking Hats further aided the positive attitude towards it because it increased the students' learning.

### □ Sub-theme: Fun and uplifting

The participants displayed a generally positive attitude towards the Six Thinking Hats, specifically pointing out that they made the process of learning more fun:

'Thinking hats is really a great teaching and learning strategy that can be used when your mind wants to work or come up with some solutions.' (Participant 97, 1st Year, Accounting)

'I was very happy that the lecturer came up with better strategies to improve our skills.' (Participant 2nd Year, Business Studies)

'It is very effective and fun to do.' (Participant 30, 3rd Year, History)

'The experience was nice and uplifting.' (Participant 27, 4th Year, Accounting)

## ▣ Sub-theme: Improving understanding and gaining knowledge

The participant's positive attitudes towards the Six Thinking Hats were encouraged by the Six Thinking Hats, improving their knowledge and understanding of their subjects:

'Thinking Hat as a strategy helps more in understanding content in a broader way.' (Participant 59, 1st Year, Accounting)

'Understanding of content.' (Participant 72, 2nd Year, Economics)

'It helps one to do understand history better and allow one to think differently.' (Participant 12, 3rd Year, History)

'Made me gain more knowledge.' (Participant 83, 4th Year, Business Studies)

Participants noted that Thinking Hats facilitated interaction and served as a platform for cooperative learning. Specifically, group work was frequently associated with the implementation of Thinking Hats within the classroom context:

'I love it because it promotes cooperative learning.' (Participant 26, 4th Year, Business Studies)

'I think thinking hats is an amazing strategy to solve a problem especially in an organisation or even in team or group schoolwork.' (Participant 100, 1st Year, Accounting)

The responses elicit the generic value of the Thinking Hats teaching strategy in a classroom. The authors believe that if learning with the Thinking Hats is experienced as fun, uplifting and invaluable for better understanding, one could argue that student confidence, independence and self-assurance to become self-regulated will flourish as the learning environment is devoid of fear.

## ■ Discussion

Critically reflecting on the data, the authors discovered that the Six Thinking Hats teaching strategy signifies benefits and limitations for cultivating metacognitive awareness and self-regulation. The Six Thinking Hats strategy holds more benefits for advancing and encouraging metacognitive awareness, as a limited number of advances were observed for promoting metacognitive regulation. It seems reasonable to argue that the acquisition of skills and dispositions empowered the students to learn autonomously (Du Toit-Brits & Van Zyl 2017, pp. 123, 125), but that efforts need to be

strengthened to invoke metacognitive regulation to organise, adjust and evaluate the learning process (Taşkin & Tüzün 2015, p. 55).

## ■ Metacognitive awareness

In the reflections, the student participants reported that skills in analysis, creative thinking, and critical thinking were cultivated. These findings align somewhat with Van Tonder et al. (2022, pp. 6–7), who state that when using the Six Thinking Hats, different modes of thinking are promoted, which include factual, evaluative, critical thinking, creative thinking, synthesis and argumentation. The students directly reported that their creative and critical thinking skills improved when they used the Six Thinking Hats. This finding could positively reflect a modest increase in the self-directedness of the students, as Morris (2021, p. 52), Ma et al. (2018, p. 8) and Liu et al. (2023) affirm that self-directed students are more likely to engage in creative thinking than less-self-directed students. The students only reported that their creative thinking improved. They did not go further in explaining or providing examples of how. It is purely their perception that their own creative thinking improved. Regarding critical thinking, Turan and Koç (2018, p. 103) similarly conclude that there is an increase in critical thinking the more an individual is self-directed. It would, however, be essential to consider teaching strategies that also stimulate the development of other vital skills for SDL, such as evaluation, making inferences and deductions and making interpretations (Bailey 2016, p. 78; Coberley-Holt & Elufiede 2019, p. 22; Uribe-Enciso et al. 2017, pp. 80, 81).

The students further reported that using the Six Thinking Hats increased their independence in their own learning and their willingness to learn with and from others. This was also evident in their desire to apply Thinking Hats in their own classrooms to promote group work and cooperative learning. Independence is a key concept within SDL, as self-directed students take responsibility for their own learning (Knowles 1975a, p. 15; Uys 2021, p. 59). Learning collaboratively and drawing knowledge from others can be partially connected to SDL as students engage with human resources to enhance their own learning (Knowles 1975a, p. 18). It was also encouraging that important dispositions for SDL, such as flexible and adaptive thinking, possibly benefitted from exposure to the Six Thinking Hats strategy (Guglielmino 2013; Obied & Gad 2017, p. 68).

To encourage the development of a more extensive repertoire of dispositions that were seemingly not supported by the Six Thinking Hats strategy, namely, perseverance, inquisitiveness and systematic working ways (Costa 2009), to mention a few, would require the incorporation of additional teaching strategies that focus on effectuating these dispositions.

## ■ Metacognitive regulation

Reporting on the application, the students stated that they analysed problems to understand them better and responded to problems considering multiple perspectives and points of view. Although they did not indicate that they evaluated the factuality of the multiple perspectives and viewpoints, they did report that their problem-solving skills improved as a result of their refined approach to analysing problems and using various perspectives or viewpoints to solve problems. These findings point to the Six Thinking Hats contributing to developing the students' ability to apply analytical thinking, which is a core critical thinking skill linked to progressive SDL behaviour (Bailey 2016, p. 78; Coberley-Holt & Elufiede 2019, p. 22; Uribe-Enciso et al. 2017, pp. 80–81). In this respect, the Thinking Hats might have guided the students to apply solutions that consisted of newer knowledge they did not possess previously, a process that a self-directed individual employs (Mahlaba 2020, p. 130). Multiple perspectives and viewpoints can lead to a more excellent grasp of the ambiguity of knowledge, leading an individual to modify the new knowledge needed for a task independently (Kallio 2020, p. 24).

Data confirming the merits of the Six Thinking Hats strategy to advance metacognitive regulation appeared limited. No clear evidence testified to the Six Thinking Hats contributing purposively to goal setting, planning learning, monitoring learning progress, evaluating the results of learning efforts, and regulating motivational and affective factors and contextual and environmental factors that could impede learning (Gonullu & Artar 2014, p. 226; Muijs & Bokhove 2020, p. 6; Quigley 2018, pp. 9–12).

Additional data showed the participants' satisfaction with the Six Thinking Hats, which was affirmed by their statements that they enjoyed and were motivated to use the hats and would use them in their classrooms to improve their students' knowledge and understanding and adapt their way of thinking. Motivation is also a key concept in SDL, encouraging students to expand their studies (Dehnad et al. 2014, p. 5184). Enjoyment could possibly be associated with the Six Thinking Hats strategy being a strategy that favours process-oriented over product-oriented learning, thus encouraging students to actively become intentional and independent thinkers about their learning (Gupta & Singh 2022, p. 331; Toh & Kirschener 2020).

The participants reported improvement in skills in analysis, problem-solving, creative thinking and critical thinking that were possibly built on their newly founded independence, incorporating multiple perspectives and viewpoints while learning and working with others. This points to an increase in metacognitive awareness as a result of their disposition or behaviour to independently incorporate multiple perspectives and

viewpoints along with working together with others' behaviours. These dispositions or behaviours then supported their problem-solving by increasing their deliberation to solve problems using the Six Thinking Hats. An individual whose behaviour allows a coordinated and controlled effort to solve problems is engaged in metacognitive regulation (Baumanns & Rott 2022, p. 1984; Papeontiou-Louca 2003, p. 11).

## ■ Limitations

In all likelihood, the four-hour exposure to the Six Thinking Hats strategy and completion of only one assignment might limit the students from fully ascertaining the strategy's effectiveness regarding metacognitive awareness and metacognitive regulation towards SDL. Nevertheless, the initial data suggest worthwhile gains, which could possibly increase with extended exposure to the strategy.

## ■ Conclusion

In conclusion, the initial results obtained from the available data reflect positive perceptions that testify to the latent potential of the Thinking Hats strategy for advancing metacognitive SDL in the following ways: (1) students seemingly experienced an improvement in the way they solved academic problems, possibly associated with the broader range of thinking modes (six skills represented by the six hats) to their disposal to evaluate potential solutions to the problems; (2) students probably became abler at organising their thoughts and articulating them explicitly in a variety of ways; and (3) the likelihood of being more open-minded about exploring alternative perspectives to solve problems. Furthermore, the data also report on the acquisition of dispositions and opportunities for cooperative work that likely invoked more engaged, out-of-the-box and adaptive thinking. Although modest, the acquired attributes testify to enhanced metacognitive awareness and metacognitive regulation processes.

Based on research findings, this chapter contributes to the body of scholarship by suggesting the Six Thinking Hats as a teaching strategy to enrich the teaching practices of pre- and in-service teachers for enhancing metacognitive SDL. In this chapter, we provided evidence that the Six Thinking Hats could be considered a teaching strategy that demonstrates moderate support for developing metacognitive awareness and metacognitive regulation. Therefore, the authors propose that consideration be given to other teaching strategies in combination with the Six Thinking Hats to optimally encourage the development of both metacognitive awareness and metacognitive regulation.



# Mathematical noticing in pre-service teacher education: Affordances for metacognition

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## ■ Abstract

Meaningful mathematics learning concerns developing sensitivity to what one notices. In order for pre-service teachers to practise mathematical noticing (attending to, interpreting and responding to their future learners' understandings), it is imperative they are exposed to learning opportunities where they can reflect on their own mathematical thinking. Noticing is defined as selecting, interpreting and acting on specific mathematical features when a variety of sources of information are presented. In this

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chapter, the focus is on mathematical noticing as reflection-on-action, where pre-service teachers re-consider, evaluate and analyse the learning experience and devise an action plan on how to improve the learning experience, or think how to act differently in future. This chapter aims to investigate the affordances of reflection on pre-service teachers' metacognitive knowledge and regulation. The study followed a basic qualitative design; two cohorts of Mathematics Education students in their third year ( $N = 46$ ) were presented with a problem-centred learning task on statistics. Based on the statistical investigative process, students had to formulate investigative statistical questions, consider the data, analyse the data and interpret the results. Students had to reflect on this experience, after which the reflections of 20 participants were analysed according to a rubric consisting of the categories of Gibbs's reflective cycle, as well as aspects of metacognitive knowledge and metacognitive regulation. An analysis of the results indicates that the students' reflection on their experience demonstrates a fair understanding of metacognitive knowledge and regulation. They can articulate what they learned, identify their strengths and weaknesses, and develop a plan to improve their learning. This is a valuable skill to have, as it can help students to become more self-directed in their learning and to develop as independent learners.

## ■ Introduction

Preparing pre-service teachers to teach mathematics for understanding, as proposed by the Mathematics Teaching and Learning framework (Department of Basic Education [DBE] 2018), is a non-negotiable aspect of teacher education (Wessels 2018). Notwithstanding the fact that a problem-centred approach is an inseparable part of teaching for understanding, in the implementation of a problem-centred teaching-learning environment where the focus is on meaningful learning, the mere completion of tasks is insufficient (Narimo, Prayitno, Fuadi, Novitasari, Setiawan, Handayani & Rahim 2021; Wheatley 1992, p. 529). Mathematical problems may offer a plethora of information, presenting possible patterns and making it challenging to process everything at once (Lobato, Hohennsee & Rhodeame 2013). Opportunities to notice and reflect on problem-solving activities play an invaluable role in the teaching-learning of mathematics. Mason (2002, p. 66) opines that the learning of mathematics involves developing one's sensitivity to noticing. Noticing is defined as 'selecting, interpreting and working with particular mathematical features or regularities when multiple sources of information compete with [sic] one's attention' (Lobato et al. 2013, p. 809). Mathematical noticing plays a central role in all teaching-learning practices and is crucial in enhancing the learning of mathematics. The practices include, but are not limited to,

'reflecting in a systematic way, recognising choices, preparing and noticing possibilities, and validating with others' (Mason 2002, p. 95). One of the aims of the Curriculum and Assessment Policy Statement (CAPS) (DBE 2011) is that the teaching and learning of mathematics should develop deep conceptual understanding in order to make sense of mathematical concepts, which can be addressed through students' mathematical thinking guided by mathematical noticing.

This chapter intends to explore how pre-service teachers (PSTs) (as students) reflect on a problem-centred lesson in statistics. By investigating students' reflection, researchers can gain a deeper understanding of the role of reflection in promoting metacognition and mathematical noticing among pre-service teachers, providing valuable insights for improving PST education programmes and preparing future mathematics teachers to effectively support student learning and mathematical development. The aim of this study is to evaluate how reflection supports PSTs in developing their metacognitive knowledge and regulation.

This chapter will be guided by the following research questions:

1. How do PSTs reflect on an activity they had to complete in a problem-centred lesson in statistics?
2. What are the affordances of reflection-on-action for pre-service teachers' metacognitive knowledge and metacognitive regulation?

## ■ Conceptual and theoretical framework

The ability of students to notice and make sense of their own thinking is closely related to students' self-regulation (including metacognition and reflection, which is visible between the interrelated skills of mathematical noticing). It is through the lens of self-regulation that the skills of mathematical noticing become a competency. In the following paragraphs, the concepts of mathematical noticing as reflection-on-action, problem-centred learning and metacognition are discussed. It concludes with an exposition of Gibbs's reflective cycle (1988).

## ■ Mathematical noticing as reflection-on-action

The intimidating nature of many mathematical problems, characterised by overwhelming information, could make it very difficult for students to process everything at once (Lobato et al. 2013, p. 809). Students may respond to this overwhelming nature of problems phenomenon by attending to only some of the aspects – an act that Lobato et al. refer to as noticing.

Although mathematical noticing (or professional noticing) is defined in literature as a teacher attending to learners' strategies, interpreting learners' understandings and deciding how to respond based on learners' understandings (Jacobs, Lamb & Phillip 2012, p. 169), we argue that PSTs should learn how to become mindful of their own experiences and thinking processes during and after problem-solving so that they may become metacognitively aware of their own teaching practices one day and so that they also model reflective thinking. Therefore, noticing is crucial, as it can lead to changed practices and provide 'new perspectives and insight' (Nel 2022).

According to Jacobs et al. (2010), mathematical noticing needs to be developed in teacher education programmes, in order for PSTs to successfully respond to complex teaching situations. The emphasis on noticing skills in preparing PSTs is also important from the viewpoint of teacher educators. Pre-service teachers can benefit from recurring reflection opportunities (Wessels 2018, p. 732).

It can be argued that individuals who are metacognitively aware of their cognitive processes are aware of what they know and what they do not know. This can assist them in planning, monitoring and evaluating and may assist students to take control of their learning processes, thereby assuming responsibility for their own learning. While reflection-in-action manifests itself during the process of acquiring knowledge, reflection-on-action occurs after the completion of the learning process (Schön 1991). Schön (1991) posits the existence of a cyclical link between the activities of studying, reflecting and taking action.

Reflection-on-action involves engaging in post-experience deliberation over the employment of acquired knowledge for future learning endeavours (Sellars 2017). The development of reflective skills holds great potential in enriching the educational experience of aspiring educators, enabling them to obtain substantial advantages from actively engaging in critical analysis and evaluation of their instructional methods. In this chapter, we argue that reflection-on-action can be compared to noticing (re-considering the situation and thinking how to act differently in future). These noticing skills can be fostered by creating opportunities to reflect on learning activities (Breen et al. 2011).

## ■ Problem-centred learning

Problem-centred learning is a teaching-learning strategy rooted in constructivism (Von Glasersfeld 1987). The surmise can be made that students will construct meaning based on their problem-solving experiences in distinctive ways. The teaching-learning process is enhanced by

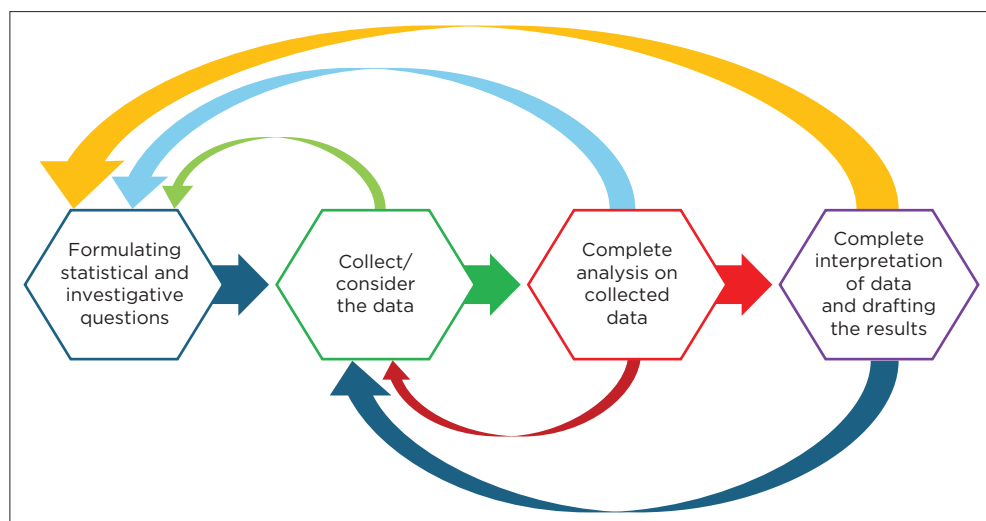
affordances to debate mathematical meaning (Wheatley 1992, p. 529). In a problem-centred lesson, tasks are presented with as little instruction or direction as possible from the teacher educator, and the students then collaboratively work on the tasks. In this study, students were exposed to a problem-centred statistical activity, where question posing is essential. The statistical problem-solving process entailed the following (see Figure 3.1).

The problem-solving process is not linear, and it is essential to ask interrogative questions throughout the problem-solving process (Arnold & Franklin 2021). When students are presented with a data set (secondary data set), the first step may be to interrogate or investigate the data, whereafter they will formulate questions or pose new interrogative questions. They will then continue to analyse the data by selecting appropriate graphical or numerical representations. The last phase in this process is to interpret the results.

## ■ Metacognition

Among the many definitions of metacognition in literature, most scholars distinguish between metacognitive knowledge concerning knowledge of one's own cognitive processes, as well as regulation of these cognitive processes (e.g. Flavell 1979; Veenman, Van-Hout-Wolters & Afflerbach 2006).

Metacognitive knowledge can be divided into three types of knowledge supporting the reflective nature of metacognition (Daradoumis & Arguedas,

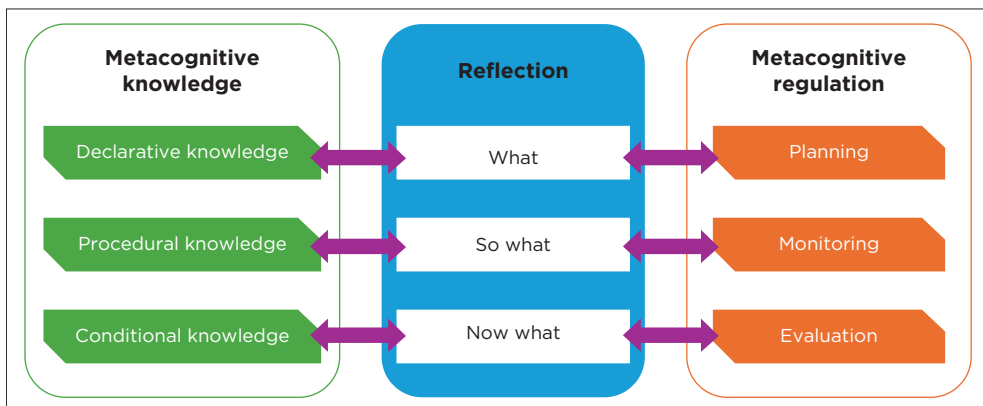


Source: Adapted from Bargagliotti & Franklin 2021, p. 3.

**FIGURE 3.1:** The statistical problem-solving process.

2020, p. 19; Schraw & Dennison 1994, p. 460), namely, declarative knowledge (Flavell 1979, p. 907; Pintrich 2002, p. 219), procedural knowledge (Vrugt & Oort 2008, p. 126) and conditional knowledge (Vrugt & Oort 2008, p.126). The primary framework that underlies conceptual mathematical discourse pertains to the significance of understanding the concepts associated with a given task (referred to as declarative knowledge, which addresses the ‘what?’), the methods and techniques employed (known as procedural knowledge, which addresses the ‘how?’) and the interconnections between all components of the task (known as explanatory knowledge, which addresses the ‘why?’) (see Figure 3.2). The desired outcome can be achieved by fostering learners’ cognitive patterns through the practice of self-questioning focused on different types of knowledge (Shilo & Kramarski 2019). This approach aims to enhance learners’ understanding of higher-order thinking skills, which in turn can facilitate the application of conceptual knowledge during classroom discussions (Kuhn 2000; Mason & Spence 2000; Zohar & Barzilai 2015).

Furthermore, metacognitive skills involve being mindful of your own learning through planning and choosing strategies, monitoring the advancement of one’s own learning, rectifying mistakes, analysing the appropriateness of one’s learning strategies and changing study habits and learning strategies if not succeeding (Brown 1987; Ertmer & Newby 1996; Shilo & Kramarski 2019; Stephanou & Mpiontini 2017). Planning pertains to choosing effective strategies and resources, monitoring refers to an individual’s awareness of understanding and task performance, and evaluating is the assessment and determination of the outcomes and planning of future goals (Schraw, Krippen & Hartley 2006). The interplay between metacognitive knowledge and metacognitive regulation, with



Source: Adapted from Rolfe, Freshwater & Jasper 2001; Schuster et al. 2020.

**FIGURE 3.2:** The conceptual framework.

reflection as the 'link' between these (Ertmer & Newby 1996), is shown in Figure 3.2.

One important aspect of all the different notions of metacognition is that knowledge and regulation of cognition are interdependent and interrelated. 'This positive relationship does not occur when metacognitive knowledge is incorrect' (Vrugt & Oort 2008). Incorrect metacognitive knowledge about students' learning processes hinders them from making the necessary adjustments to their learning strategies (Veenman et al. 2006; Vrugt & Oort 2008). According to Panaoura and Philippou (2005), metacognitive knowledge leads to improved regulation, and improved regulation results in the configuration of new metacognitive knowledge.

Self-regulated learning is important in developing lifelong learners, especially in the case of pre-service mathematics teachers who will soon be models of intentional teaching-learning in their own classrooms. Kramarski et al. (2013) assert that learners are self-regulated to the extent that they are 'cognitively and metacognitively motivated and behaviourally active participants in their own learning process' (p. 1).

## ■ Gibbs's reflective cycle

Gibbs's (1988) reflective cycle proposes a reciprocal enhancement between theory and practice within a continuous cycle (Finlay 2008). As stated by Gibbs (1988), this model facilitates a systematic and analytical manner for students to engage in introspection regarding their experiences (reflection-on-action), hence fostering self-awareness and empowering them to adapt and adjust their behaviour as needed. Gibbs's reflective cycle encourages students to reflect on their ideas and feelings and consider how they might react in similar situations (Sibson 2008). Gibbs's reflective cycle comprises six discrete elements that include describing the experience, exploring associated emotions, evaluating successful and unsuccessful elements, analysing the experience, making conclusions on the student's learning and creating a future action plan. Based on the work of Refugio et al. (2020), we have combined the stages of evaluation and analysis, resulting in five stages, instead of six.

The first step of the process is the description stage, wherein students provide a detailed account of the exact details pertaining to the given situation. Students actively participate in the analysis of their emotions and thoughts during the entirety of the interaction in the segment specifically devoted to the exploration of sentiments before they evaluate the experience by offering either positive or negative assessments. The judgement of the relevance of the circumstance is subjected to intense scrutiny by students during the analysis phase. Then, students engage in

the observation and consideration of other options. Ultimately, in the action plan phase, students actively participate in the cognitive process of visualising strategies for efficiently navigating parallel scenarios (Gibbs 1988).

In Table 3.1, a short summary is provided on how each of the five stages in Gibbs’s reflective cycle was analysed.

**TABLE 3.1:** Analytical framework for the five stages of Gibbs’s reflective cycle.

Category	Manifestation
Description	Students provide a clear and focused description of the problem-solving experience and activity.
Feelings	Students provide an explanation of their intellectual and emotional responses.
Evaluation and analysis	Students evaluate the activity in terms of positive and negative experiences. What went well? What could have been improved?
Conclusion	Students identify aspects that could have been done differently in this experience.
Action plan	Students are able to list possible actions that they will take when the experience arises again.

Source: Gibbs 1988.

## ■ Research design and methodology

This study involves a qualitative research methodology where a basic qualitative design was used to answer the research questions. A basic qualitative design is underpinned by constructivism (Merriam & Tisdell 2016, p. 24), where the researcher is interested in how participants interpret their experiences and what meaning they attach to their experiences. The overarching objective is to comprehend how people make sense of their experiences (Merriam & Tisdell 2016, p. 24).


## ■ Research method

The participants in this study consisted of two cohorts of Mathematics Education students (two different campuses;  $N = 46$ ) in their third year, taking a mathematics module on statistics (and probability). The whole group participated in the data collection process, as it was part of the module assessment plan. Students were presented with an investigative statistics problem, where they had to apply the statistical problem-solving process. Afterwards, they had to reflect on the activity by answering guiding questions based on Gibbs’s reflective model. The reflections of 20 participants were analysed by using the six dimensions of Gibbs’s reflective

cycles, as well as the categories of metacognitive knowledge and metacognitive regulation. Informed consent was obtained from participants, with the assurance that their identity will remain confidential. Their reflective activities did not affect their marks in any way, as these data were not used for grading purposes.

Based on the statistical investigative process (Figure 3.1), students had to answer open-ended questions (see Appendix 1). Students then had to formulate investigative statistical questions, consider the data, analyse the data and interpret the results. Here is a short excerpt from the problem-centred learning task:

Here are photos of the Asian lady beetle, one of the most variable species in the world with a range of colour forms.



**A. Ask:**

- Write down at least two statistical investigative questions for the ladybugs pictures.
- What is the statistical investigative question your group will use for the lesson?

**B. Collect**

- For each investigative question in the table below, create one or more data collection question/s to pose as you consider the pictures of the ladybugs?

Interrogative questions
How many spots do ladybugs typically have? (General about the group)
Do red ladybugs tend to have more spots than black ladybugs?

- Create a spreadsheet using Excel or Google Sheets with the following headings and information included. Use the properties of the spreadsheet to explore the data collected there. What new questions do you have about the data?

**C. Analyse**

Create dot plots for each of the categories of data assigned to your group.

**D. Interpret**

Based on the data collected and analysed, interpret your results

Source: Adapted from Bargagliotti et al. 2020.

**FIGURE 3.3:** Mathematical task.

On completion of the activity, students completed a reflection based on Gibbs's reflective cycle (see Appendix 2):

1. DESCRIBE: What happened? Where? To whom? Why? When?
2. FEELINGS: What were you thinking and feeling?
3. EVALUATION and ANALYSIS:
  - What was good about the experience?
  - What was bad about the experience?
  - What sense can you make of the experience?
  - What did you learn about the concept or topic during this activity?
  - What do you understand better?
  - What do you still don't understand?
  - What worked? Why?
  - What didn't work? Why?
4. CONCLUSION: What else could you have done in this experience?
5. ACTION PLAN: If it arises again (next time), what would you do **differently?**

## ■ Ethical considerations

This study involved pre-service teachers (3rd-year Mathematics Education students) and is part of a larger study on open educational practices for self-directed learning (SDL). The study was approved by the Education Sciences Research Ethics Committee (EduREC) (Ethics number NWU-01014-21-A2) of North-West University. Although the activities (reflections) that the students completed were part of the assessment plan in the module, participants had the opportunity to give written consent for their reflections to be used as data in this research study. Participants were ensured that the data collected from them through the reflection tasks will remain confidential. Their identity has not been revealed at any stage, and they were given the assurance that, should they not wish to give informed consent, their module marks would in no way be compromised.

## ■ Data analysis

Data were analysed through a priori coding (Nieuwenhuis 2007), informed by the stages of Gibbs's reflective cycle, as well as the components of

metacognitive knowledge and metacognitive regulation. Firstly, the five stages of Gibbs's reflective cycle were used as codes, and then within each of the five stages, the aspects of metacognitive knowledge and regulation were identified. A1 to A20 were used as pseudonyms for the participants.

## ■ Findings and discussion

The responses of the students were summarised below according to the phases of Gibbs's reflective cycle.

### ■ Description phase

In the description phase, students had to indicate what happened, where, to whom, why and when. In this section of Gibbs's reflective cycle, the students discussed their experience of participating in group work and coming up with investigative questions about the statistical problem that was posed to the students. They also mention graphically representing their evidence in the form of graphs. The exercise was more challenging than previous ones, and they were not sure how it would fit into their work. Learning about the 'procedure for gathering data and analysing it before drawing conclusions was a useful experience' (A19, gender undisclosed, 27 February 2023). Students wanted to make conclusions based on their findings and recognised that everyone has their own 'perspective on different questions' (A17, gender undisclosed, 27 February 2023). They also mentioned that different characteristics of the ladybugs can be 'due to the different environment that they live on' (A2, gender undisclosed, 27 February 2023). One student 'missed the first class' (A3, gender undisclosed, 27 February 2023), and another student was 'excited for a second chance to prove himself' (A6, gender undisclosed, 27 February 2023). The experience demanded critical thinking and problem-solving skills as 'I learned to be more critical in not only this topic statistics but in everything I tackle' (A4, gender undisclosed, 27 February 2023). The students wondered what would have happened if they had collected the data independently. The level of difficulty increased throughout the statistical problem-solving process, including analysing 'datasets that are larger and not necessarily clean for analysis' (A7, gender undisclosed, 27 February 2023). Students exhibiting elevated levels of metacognitive abilities are more likely to accurately solve problems through the utilisation of suitable techniques, mathematical notations and logical reasoning (Güner & Erbay 2021).

The following metacognitive knowledge types can be identified in the summary:

**Declarative knowledge:** The students realised that the exercise was more challenging than previous ones, that everyone has their own perspective on different questions (A17, gender undisclosed, 27 February 2023) and that different characteristics of ladybugs can be attributed to different environments.

**Procedural knowledge:** The students know how to participate in group work, 'however manage by speaking to my peers' (A3, gender undisclosed, 27 February 2023), come up with investigative questions about statistics and made use of different ways to solve the problem by graphically 'represent(ing) my evidence in the form of graphs' (A4, gender undisclosed, 27 February 2023).

**Conditional knowledge:** The students realised that critical thinking and problem-solving skills are demanded in this type of exercise. Students were challenged to 'ask(ing) analysis questions to compare the characteristics of the groups, problem-solving and critical thinking skills' (A7, gender undisclosed, 27 February 2023) and needed to 'increase my critical thinking in the manner that I was thinking very hard in coming up with suitable questions' (A6, gender undisclosed, 27 February 2023). The response of A7 (gender undisclosed, 27 February 2023) indicates that the 'transition of levels was becoming more advanced with the types of questions passed throughout the statistical problem-solving process, considering datasets that are larger and not necessarily clean for analysis, and using more tools and methods for analysing the data' is an indication that students also realised that the level of difficulty increases throughout the statistical problem-solving process.

The above discussion illustrates how students demonstrate metacognitive knowledge in different ways. Some students are more aware of their own learning process than others. However, all the students in the summary are able to reflect on their experience and identify areas for improvement.

In addition to these three types of metacognitive knowledge, the summary also reveals the students' metacognitive awareness and regulation. They are aware of their own strengths and weaknesses, and they are reflective about their learning process: 'it was quite daunting to do this activity on my own' (A3, gender undisclosed, 27 February 2023) and 'we had never gotten into the work as deep as we did this semester' (A4, gender undisclosed, 27 February 2023). They mention that they were not sure 'what variables we were investigating and the graph we were asked to draw' (A17, gender undisclosed, 27 February 2023), how the exercise would fit into their work and they wonder what would have happened if they had collected the data independently. Student A19 (gender undisclosed, 27 February 2023) also 'discovered that the questions that must be

answered before a statistical inquiry, such as what they notice and what they believe, appear to be simple enough'. Understanding that pertains to the ability to take appropriate action in a given situation (Mason & Spence 2000; Schraw 1998) is an important aspect of mathematical noticing. This necessitates the acquisition of skills that enable individuals to be cognisant of their knowledge, actions and the necessary measures to regulate their implementation (Shilo & Kramarski 2019)

Overall, the summary provides a good example of how students can demonstrate metacognitive knowledge in a variety of ways. The students can articulate their understanding of the task, their own cognitive processes and the factors that influence their learning (Ambrose et al. 2010, p. 6; Shilo & Kramarski 2019; Sindhawani & Sharma 2013, p. 68).

The fact that the students were excited for a second chance to prove themselves suggests that they can motivate themselves to learn. A study by Abdelrahman (2020, p. 6) confirmed a correlation between metacognitive awareness and intrinsic academic motivation. Overall, the students' reflections provide a good example of how metacognitive regulation can be used to enhance learning.

## ■ Feelings phase

In this phase of Gibbs's reflective cycle, students had to explain what they were thinking and feeling. The students had a range of intellectual and emotional responses to their experiences in this phase. Some felt 'overwhelmed by the fact that statistics is a very complex topic' (A4, gender undisclosed, 27 February 2023), while others felt 'privileged be able to do what we were doing in statistics because it is such a complex topic' and 'we had never gotten into the work as deep as it was this semester' (A4, gender undisclosed, 27 February 2023). Some students found that practice helped them understand and answer questions, while others were inspired to learn more about the role of statistics in society (A5, gender undisclosed, 27 February 2023). The experience was described as interactive, interesting and informative. However, some students felt unsure or confused, lacking 'background of what exactly was the purpose' (A14, gender undisclosed, 27 February 2023) and 'felt like we were not serious until later on when I saw questions relating to statistics' (A17, gender undisclosed, 27 February 2023). There was also a sense of uncertainty about asking the right questions and fitting the topic into the bigger picture, as 'the investigation was without meaning' (A14, gender undisclosed, 27 February 2023). One student made connections between temperature and colour, drawing parallels to human differences. In addition to the three types of metacognitive knowledge listed above, the summary also reveals the students' emotional

responses to the experience. The students felt unmotivated and ‘bit confusing as to how we are to tackle the questions in this investigation’ (A1, gender undisclosed, 27 February 2023). They also found the activity to be tedious and boring at times. These emotional responses can have a significant impact on students’ learning. However, the students were able to overcome these challenges by asking for help from the lecturer and learning from their peers, as well as ‘collecting data and coming up with a plan’ (A12, gender undisclosed, 27 February 2023).

The summary testifies to how metacognitive knowledge and emotional regulation can be used to enhance learning. Students who can monitor and regulate their own cognitive and emotional processes are more likely to be successful learners.

In the reflection, the students do not explicitly mention motivation, managing time and resources, and emotions, but it is possible that they are also using them to regulate their learning. For example, the fact that they were able to overcome their initial lack of motivation suggests that they can motivate themselves and shows ‘self-discipline and dedication’ (A3, gender undisclosed, 27 February 2023).

The following metacognitive knowledge types can be identified in the summary:

**Declarative knowledge:** The students know that statistics is a complex topic, that practice can help them understand and answer questions, and that statistics plays a role in society. They also know that they can learn more about the topic as the ‘feeling of curiosity was in my mind’ (A5, gender undisclosed, 27 February 2023) and am ‘eager to explore and find out more about it’ (A4, gender undisclosed, 27 February 2023).

**Procedural knowledge:** Some students found that practice helped them understand and answer questions as ‘practice makes perfect’ (A5, gender undisclosed, 27 February 2023). This suggests that they know how to learn statistics.

**Conditional knowledge:** The students know that asking the right questions is important, but they may not be sure how to do this. They also know that the topic of statistics may not fit into the bigger picture for them.

**Metacognitive awareness:** The students are aware of their own strengths and weaknesses. For example, some students admit that statistics is not their strong suit and that they are still ‘unsure it’s still how statistics work when it comes to looking at things more closely’ (A4, gender undisclosed, 27 February 2023). Others are able to make connections between statistics and other topics, such as human differences and data collection methods.

Students who can monitor and regulate their own cognitive and emotional processes are more likely to be successful learners (Temircan 2023).

The students in the summary express a range of emotions in response to the experience, such as excitement, fear and confusion. These emotions can have a significant impact on students' learning. However, students who are able to regulate their emotions are more likely to be successful learners.

Overall, the summary suggests that some students in the group can demonstrate metacognitive regulation in their learning. They can plan, monitor and evaluate their learning, and they are able to identify areas where they need to improve. According to Flavell (1979), metacognition plays a crucial role in comprehending the job at hand, choosing an appropriate solution method and assessing the efficacy of the selected technique. However, other students in the group may need more support in developing their metacognitive regulation skills.

## ■ Evaluation and analysis phase

A reflection on what was good and bad about the experience, what worked and what not, and what students understand and what not follows in the evaluation and analysis phase of Gibbs's reflective cycle. On the positive side, the problem-centred activity allowed for interaction with others and thinking about ladybugs. It also involved investigating ladybugs and thinking about more complex questions viewing them in relation to statistics 'as we can apply statistics in so many different thing(s) in real life to solve problems' (A4, gender undisclosed, 27 February 2023; A18, gender undisclosed, 27 February 2023). Teaching instruction has an impact on the effectiveness of knowledge activation. Specifically, the reflections of the students highlight the importance of factors such as task selection, knowledge construction in the classroom and the role of the teacher as a facilitator in fostering productive teacher-student learning interactions (Kramarski 2017). These conclusions align with previous studies conducted by Borko et al. (2015), Kramarski (2017) and Van Beek et al. (2014).

There was also the opportunity to be exposed to various 'perspective(s) when it comes to different questions' (A17, gender undisclosed, 27 February 2023) and the formulation of questions, which served as invaluable learning points. It can be inferred that the experience of working on statistics in this activity was mostly positive as they can 'relate some pictures to mathematics if only they think deeply and create questions out of the pictures about the topic they will be teaching' (A17, gender undisclosed, 27 February 2023). The students understood the concepts and terms related to statistics, such as calculating and analysing data. They also developed problem-solving and 'critical' (A4, gender undisclosed, 27 February 2023) thinking skills through

comparing characteristics and asking 'analysis questions to compare the characteristics of the groups' (A8, gender undisclosed, 27 February 2023). The collaborative group work appeared to be successful. The activity 'increases my critical thinking in the manner that I was thinking very hard in coming up with suitable questions which will make the investigation more relevant' (A6, gender undisclosed, 27 February 2023). In light of the widespread adoption of a problem-centred approach in the context of pedagogy aimed at fostering understanding, it is crucial to underscore the creation of an instructional environment centred around problem-solving that places greater emphasis on meaningful learning as opposed to mere completion of tasks (Narimo et al. 2021; Wheatley 1992, p. 529).

However, there were some challenges: At the beginning, one group struggled to 'come up with differences' (A1, gender undisclosed, 27 February 2023) of ladybugs. In the investigation regarding ladybugs, there was a lack of 'proper activities to prepare us for this particular one' (A4, gender undisclosed, 27 February 2023), which made it confusing as 'how we are to tackle the questions in this investigation' (A4, gender undisclosed, 27 February 2023) initially. The students also found it challenging to memorise new formulas quickly (A5, gender undisclosed, 27 February 2023). Furthermore, the activity 'was too long, everyone's data looked different' (A13, gender undisclosed, 27 February 2023), and counting the spots on ladybugs was tedious and boring (A15, gender undisclosed, 27 February 2023). Initially, the students also felt unmotivated and unsure of what to do (A15, gender undisclosed, 27 February 2023). The students also highlighted the importance of not to 'underestimate how mathematics might be taught by different lecturers' and the need to 'see the questions that were related to statistics before theoretical ones' (A17, gender undisclosed, 27 February 2023).

Overall, the students found value in the experience, such as learning about ladybugs, formulating questions, collecting data and working in groups as they 'could learn from one another' (A16, gender undisclosed, 27 February 2023). They also appreciated the help from the lecturer and the opportunity to learn (A17, gender undisclosed, 27 February 2023) and 'work(ing) in pairs since we were discussing after classes' (A17) and did not 'know that (ladybugs) exist in so many looks' (A18, gender undisclosed, 27 February 2023).

The following metacognitive knowledge types can be identified in students' responses:

**Declarative knowledge:** The students recognised that the experience allowed for interaction with others, 'work in pairs, could compare thinking' (A15, gender undisclosed, 27 February 2023) for 'greater understanding' (A15, gender undisclosed, 27 February 2023). They also know that the

experience was challenging at times and that there were areas for improvement. They also developed problem-solving and critical thinking skills through comparing characteristics and formulating questions. 'It improved my ability as an individual to appropriately discover, determine, and discern the right meaning of the information' (A6, gender undisclosed, 27 February 2023).

**Procedural knowledge:** The students learned how to formulate questions, collect data and work in groups. The 'students could learn from one another' (A10, gender undisclosed, 27 February 2023) and ask for help when needed. Student A17 indicated that 'everyone has their own perspective, working in pairs, discussing and engagement with lecturer' (A17, gender undisclosed, 27 February 2023).

**Conditional knowledge:** The students realised that statistics is important in real-life applications and that it is important to approach statistical questions before theoretical ones.

**Self-awareness:** The students are aware of their own strengths and weaknesses. For example, they know that they can find it challenging to memorise new formulas quickly.

They are also aware of their own emotions, and they were able to identify factors that contributed to their initial lack of motivation (Abdelrahman 2020). Students realise that they are hardworking and cooperative, but they also know that they can doubt the quality of their work and find it difficult to draw graphs on a computer. Student A13 indicated that the 'activity tested knowledge' and that he/she wants to do more activities like this' (A13, gender undisclosed, 27 February 2023). 'I learned to be more critical in not only this topic statistics but in everything I tackle. I now understand how to structure questions involving statistics, how to answer statistical questions and also how to analyse data in such a way that the information is valuable to my investigation' (A4, gender undisclosed, 27 February 2023) indicates that students know what exactly is being expected of them.

Overall, the summary provides evidence of how a student can demonstrate metacognitive knowledge in a variety of ways. The students can articulate their understanding of the experience, their own cognitive processes and the factors that influence their learning.

The students' reflection on the experience provides a good example of how metacognitive regulation can be used to enhance learning. The students can plan, monitor and evaluate their learning, and they are able to identify areas where they need to improve.

By using metacognitive regulation, the students can take control of their own learning and improve their performance.

## ■ Conclusion phase

Students identified several things that could have been done differently in this experience.

The following metacognitive knowledge types can be identified in this phase of Gibbs's reflective cycle:

**Declarative knowledge:** The students recognised that there are several things that could have been done differently in the experience, such as conducting more research on the investigation question, using software to process data, working more collaboratively in groups, studying the habitat and other factors that could affect the colours of ladybugs, collecting more data, coming to class more prepared, conducting a more detailed investigation with better background research and investigating more information on the given pictures of ladybugs to ensure the experiment's accuracy as 'some of the colours weren't as evident and we disagreed on which colour they should be categorised under' (A19, gender undisclosed, 27 February 2023).

**Procedural knowledge:** The students realised that they should attend class, conduct research, use software, collaborate with others, study, collect data and prepare for class.

**Conditional knowledge:** The students are aware that conducting an investigation and exploring information can improve the accuracy and quality of an experiment.

Overall, the conclusion phase provides a good example of how a student can demonstrate metacognitive knowledge by identifying areas for improvement in their own learning.

Overall, analysis of the reflections demonstrates that students are able to regulate their own learning by identifying areas for improvement, planning for future learning and monitoring their progress.

## ■ Action plan phase

The following metacognitive knowledge types were identified in the action plan phase of Gibbs's model, which focuses on what the students will do differently when the experience arises again.

**Declarative knowledge:** Students realise that it is important to thoroughly understand the theory before applying it practically '...I will make sure to thoroughly understand the theory before applying it practically'.

**Procedural knowledge:** Students understand the importance of the 'purpose of each experiment' (A18, gender undisclosed, 27 February 2023),

to involve more group members or use additional resources, to revise the relevant material and to seek guidance from their peers and lecturer.

Conditional knowledge: They know that it is important to thoroughly understand the theory before applying it practically because this will help them to avoid making mistakes and to solve problems more effectively. They also know that it is important to bring a laptop to class to make it easier to work on the assignments, to aim for clearer pictures so that they can better understand the data, to ask their peers questions if they are struggling to understand a concept, to ask questions before formulating an investigative question so that they can be sure that they are asking meaningful questions, to involve more group members or use additional resources to ensure efficient work because this will help them to learn from others, and to revise the relevant material and seek guidance from their peers and lecturer to enhance their understanding and problem-solving abilities in statistics because this will help them to solidify your learning and to get the support you need to succeed.

In summary, the students' plan for learning and improving their skills in statistical problem-solving demonstrates a strong understanding of metacognitive knowledge (Santoso, Napitupulu & Amry 2019). Students can articulate the strategies that they will use to learn and to identify the factors that will influence their success. This awareness will help them to take control of their own learning and to achieve their goals.

Overall, the action plan of the students demonstrates an understanding of metacognitive regulation strategies. By planning, monitoring and evaluating their learning, they can increase their chances of success in statistical problem-solving.

## ■ Conclusion

It seems as if the opportunity to reflect on this problem-centred activity engaged the students in metacognitive knowledge and regulation. This resonates with Mason's (2002) assertion that mathematics learning involves developing one's sensitivity to noticing.

Metacognitive strategies enable students to evaluate their own learning (Okoro & Chukwudi 2011). Some recommendations for using metacognitive regulation to improve learning are discussed below.

Set specific and measurable goals. What do you want to achieve by learning statistics? Once you know your goals, you can develop a plan for how to achieve them.

Identify your strengths and weaknesses. What are you good at? What areas do you need to improve in? Knowing your strengths and weaknesses can help you to focus your learning efforts.

Break down complex tasks into smaller steps. This will make them seem less daunting and more achievable.

Use a variety of learning strategies: There is no one-size-fits-all approach to learning. Experiment with different strategies, such as reading, listening, watching videos and doing practice problems, to find what works best for you.

Take breaks. Your brain needs time to process and consolidate information. Take breaks every 20–30 minutes to get up and move around, or to do something else that you enjoy.

Reward yourself for your accomplishments. This will help you to stay motivated and on track.

In general, with regard to Gibbs's reflective cycle, the students reported mixed experiences with the statistics activity. They found some aspects of it challenging, but also recognised the value in learning about statistics and applying it to real-life situations. They identified areas for improvement, such as better preparation and clearer instructions. They also developed an action plan to improve their skills and understanding of statistical problem-solving. Overall, the students found value in the experience but acknowledged the need for improvements.

Metacognitive knowledge and regulation could be identified in the reflection of the students' experience with the statistics activity. The students' reflection on their experience demonstrates a good understanding of metacognitive knowledge and regulation. The reflection-on-action, or noticing activities, created opportunities for PSTs to be aware of metacognitive knowledge and regulation. They can articulate what they learned, identify their strengths and weaknesses, and develop a plan to improve their learning. This is a valuable skill to have, as it can help students to become more independent and successful learners.

## Appendix 1

In this problem, we will make use of summary and comparative investigative questions, based on the outcomes of the study unit.

Here are photos of the Asian lady beetle, one of the most variable species in the world with a range of colour forms.



**What do you notice?**

- 1.
- 2.
- 3.

**What do you wonder?**

- 1.
- 2.
- 3.

**A. Ask**

Write down at least two statistical investigative questions for the ladybugs pictures.

What is the statistical investigative question your group will use for the lesson?

**Interrogate the statistical investigative question:**

Answer the following questions regarding the statistical interrogative question and this scenario:

Interrogative questions	Answers
Who or what population of ladybugs are we wanting to know about?	
What variable(s) are we investigating?	
Can you answer the investigative question with the information you have in the photo?	

**B. Collect**

For each investigative question in the table below, create one or more data collection question/s to pose as you consider the pictures of the ladybugs:

Interrogative questions	Data collection questions
How many spots do ladybugs typically have? (General about the group)	
Do red ladybugs tend to have more spots than black ladybugs?	

- a. Fill in the data cards provided for Ladybug number, number of spots, colour of body, and colour of the spots.
- b. What new questions do you have about the data now that you have collected it within these individual tables?

Create a spreadsheet using Excel or Google Sheets with the following headings and information included. Use the properties of the spreadsheet to explore the data collected there. What new questions do you have about the data?

Ladybug #	Number of spots	Colour of body	Colour of spots
1	6	R	B
2	10	O	B
...			

**C. Analyse**

Create dot plots for each of the categories of data assigned to your group:

Assigned categories for creating a distribution:

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**Questions to address:**

- What number of spots were the most common/typical for the red ladybugs? Orange ladybugs? Black ladybugs?
- What number of spots were the most common/typical for all the ladybugs?
- If you are told the ladybug has four spots, what colour do you think the ladybug is?
- Is the choice of display the most appropriate for the data? How do you know?
- What other features of the data could be found? Explain.
- Have you answered the investigative question? Explain your answer.

**D. Interpret**

Based on the data collected and analysed, interpret your results. Remember that evidence should be cited when answering the statistical investigation question (i.e. interpreting the results):

1. How many spots do ladybugs typically have?
2. Do red ladybugs tend to have more spots than black ladybugs?
3. Does the interpretation answer the investigative question?
4. Does this make sense with what we know about ladybugs?

## ■ Appendix 2

Make use of the reflection template provided below and reflect on the Lady Bug activity.

### REFLECTION LESSON (ONE PAGE)

I am writing this reflection to provide evidence of... (Topic/concept)

1. DESCRIBE: What happened? Where? To whom? Why? When?
2. FEELINGS: What were you thinking and feeling?
3. EVALUATION: What was good about the experience?

What was bad about the experience?

4. ANALYSIS: What sense can you make of the experience?

What did you learn about the concept/topic during this activity?

What do you understand better?

What do you still don't understand?

What worked? Why?

What didn't work? Why?

5. CONCLUSION: What else could you have done in this experience?
6. ACTION PLAN: If it arose again (next time), what would you do **differently?**



# Metacognitive reflection based on a selection of history game genres to develop self-directed learning<sup>2</sup>

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## ■ Abstract

The promise of game-based learning (GBL) across a wide range of educational settings has left many educators wondering how to best pick instructive video games for their individual settings. The best methods, guidelines, processes and/or criteria for deciding upon instructive video games are important considerations for teacher practice. Variety in genre, play style, medium, difficulty, goal(s), etcetera, is almost limitless. The study's primary objective is to determine and investigate the role that video games play in facilitating successful GBL, which in turn may facilitate self-directed learning (SDL) among third-year Bachelor of Education students. Students' perspectives and experiences with video game selection are investigated to see whether particular SDL traits are evident. With the use of online interviews conducted with 10 Bachelor of Education students with History as a major at a South African university, it may be possible to develop standards for better GBL selection and implementation in higher education settings throughout the world. The theoretical framework focuses on Situated Learning and Cognitive Apprenticeship, Flow Theory and Constructivist Learning. The study utilises a qualitative hybrid video and interview methodology to collect data on participant impressions, motivating factors, difficulty and educational value of GBL selection for Higher Education settings. Participants' opinions on utilising video games for history education illuminate the dynamic relationship between SDL and metacognition in the classroom. These findings show how video games like *Assassin's Creed*, *Valiant Hearts*, *Crusader Kings III* and others may help students actively interact with historical knowledge, create learning goals and track their progress. The participants' reflections on the cognitive methods needed to use these games for instruction underline the metacognitive aspect of this process. The analysed results serve as a solid foundation upon which to build a practical applied framework for such a setting.

## ■ Introduction

An essential competency in today's global labour market, self-directed learning (SDL), has become a prominent focus of academic enquiry in the 21st century. Employees who can be given an issue to solve on their own, and who can be trusted to do it efficiently and with a minimal waste of resources, are highly sought after (Regan 2003, pp. 593–599).

Self-direction, as stated by Loyens, Magda and Rikers (2008, pp. 411–427), is an important prerequisite for the future for which we are educating our students. A serious problem prevailing with traditional teaching approaches

in history education in the last decade has been identified. The traditional classroom culture of direct instruction that has been passed down is not one that encourages students to take initiative, but rather one that emphasises compliant consumption, an un-flipped paradigm in which students simply listen to their teachers, take notes and then use essays, assignments and tests to show that they have learned the material (Deterding et al. 2011, pp. 14-17).

A game-based learning (GBL) strategy is proposed to counteract this tendency of direct instruction in history classes. For over three decades, GBL has been discussed in the field of education. The vast majority of today's youngsters are avid gamers (Deterding et al. 2011, pp. 14-17). Feelings of success, growth and victory over an opponent, as well as constructive criticism and gratifying rewards in GBL, are what keep people coming back for more. By putting students in charge of their own education, GBL has the potential to tap into powerful sources of intrinsic motivation, an important aspect of SDL. When implemented properly, GBL has the potential ability to enhance intrinsic motivation by introducing social connection and providing openings for extrinsic motivators like leaderboards. Inspiring users to take action may be a real challenge, but a well-executed GBL approach can (Hamari, Koivisto & Sarsa 2014, pp. 3025-3034).

Playing educational games in the classroom has numerous advantages for students:

- safer forms of competing
- enhancement of soft skills (social and emotional development)
- focus on the individual student
- encouraging child's memory to develop further
- competence with computers and simulations
- critical and creative problem-solving abilities (Hamari et al. 2014, pp. 3025-3034).

As such, the goal of this research was to use a GBL strategy to help pre-service teachers become more adept at learning on their own initiative. This study is driven by the research question, 'How do third-year Bachelor of Education in History majors see GBL, game selection and their potential impact on SDL?' The study's primary objective is to determine and investigate the role that video games play in facilitating successful GBL, which in turn may facilitate SDL among third-year Bachelor of Education students. The following secondary questions helped to achieve the main research question: What are students' perspectives and experiences with video game selection? What particular SDL traits are fostered with video game selection and GBL?

## ■ Conceptual and theoretical framework

This chapter opens with an orientation towards the concepts and theories considered on the value of self-direction in today's Higher Education and the ways in which GBL has the capacity to promote SDL and facilitate metacognition. Following this, the chapter's conceptual framework is deconstructed in terms of its connections to SDL, GBL and video games. The next part is broken down into subheadings for the 'Role of video games in self-directed learning and metacognition', 'Video games and self-directed learning', 'Autonomy and choice in video games', 'Feedback and reflection', 'Problem solving and critical thinking', 'Video games and metacognition', 'The metacognitive cycle' and 'Reflection and strategy development and the transfer of metacognitive skills'.

### ■ Conceptual framework

Three key concepts are central to this project, namely, SDL, GBL and video games. All flow from one another, with SDL being the central main theoretical underpinning.

### ■ Self-directed learning

Self-directed learning, in its broadest sense:

[R]efers to the process by which individuals take the initiative, with or without the help of others, to diagnose their learning needs, formulate learning goals, identify human and material resources for learning, choose and implement appropriate learning strategies, and evaluate learning outcomes. (Knowles 1975, p. 18)

Two of SDL's defining features are (1) the student's ongoing, genuine control over all learning-related choices and (2) the student's access to and freedom to choose from a wide variety of suitable resources (Knowles 1975, p. 18).

### ■ Game-based learning

Most explanations of what 'game-based learning' include, emphasises that it is a specific kind of gaming designed to achieve certain educational goals (Shaffer, Halverson, Squire, & Gee, 2005, p. 105). However, it is not always the case that the game is a digital one. A consequence of this statement is that while designing games for education, it is necessary to strike a balance between the two goals of comprehensively covering the content highlighted in the curriculum and making the games themselves

the primary focus (Plass, Perlin & Nordlinger 2010, online). There is a clear separation between game-based education and gamification, as shown by this corollary. While there is no universally agreed-upon definition of the term ‘gamification’, it often refers to ‘the incorporation of game mechanics, such as point systems and leaderboards, into non-game contexts in order to increase participation in such settings’ (Parapanos & Michopoulou 2021, p. 13). Academics are still debating what constitutes and what does not constitute a game (Salen & Zimmerman 2004, p. 80; Yusof & Shahrill 2021, p. 27). A game may be thought of as ‘a system in which participants participate in a manufactured conflict, defined by rules, that results in a measurable conclusion’, according to one description (Salen & Zimmerman 2004, p. 80). The gamification of arithmetic homework, for instance, can entail awarding students points and stars for completing mundane tasks. In contrast, utilising a gaming approach to teach the same mathematical concept would include rethinking the assigned homework by introducing artificial conflict and rules of play to make the material more exciting and engaging for the student.

Play, the core action in games, has long been seen as an important part of human development; therefore, it is not a big deal if the issue over how games are defined cannot be settled here.

## ■ Video games used in the study

The following video games were shown to participants in the form of edited trailers (clips) and questions on these followed afterwards: ‘Assassin’s Creed’ (Ubisoft 2007), a third-person action game centred around the Medieval crusades; ‘Valiant Hearts, The Great War’ (Ubisoft Montpellier 2014), a puzzle adventure game set during the First World War; ‘Crusader Kings III’ (Paradox Interactive 2022), a grand strategy game set in Medieval Europe; ‘Ghost of Tsushima’ (Sony Interactive Entertainment 2020), an action-adventure game that interprets the Mongol invasion of Japan; ‘Total War, Rome II’ (Sega 2013), a tactical strategy game revolving around the ancient world, where players control a wide range of ancient nations, focusing on economy, military and political strategies; and ‘Age of Empires III’ (Microsoft Game Studios 2005), a real-time strategy game with the colonial period as backdrop, where players control European, Native American and African nations in the additional content packs released for the game (downloadable content [DLC]).

The following section outlines how GBL can influence SDL and metacognition.

## ■ The role of video games in self-directed learning and metacognition

The rapid evolution of digital technologies has transformed the landscape of education and learning in recent years (Balyk et al. 2020, p. 7). One of the most prominent and intriguing aspects of this transformation is the role that video games play in facilitating SDL and metacognition (Foster et al. 2019, p. 640). Video games, traditionally seen as a form of entertainment, have increasingly been recognised for their potential to engage learners in self-directed, immersive and cognitively stimulating experiences (Grant, Spears & Pedersen 2018, online). This theoretical literature review explores the multifaceted relationship between video games, SDL and metacognition, shedding light on how these elements intertwine and impact educational outcomes.

The use of video games in educational contexts has been of particular interest to educational scholars because of their potential to promote SDL and metacognition. Although video games were originally perceived as leisure activities, they are now understood to be effective in promoting engagement and cognitive stimulation because of the immersive quality of the game experience (Tokac, Novak & Thompson 2019, p. 67).

According to Gordillo, Barra and Quemada (2021b, p. 112), educational video games have been found to improve learning outcomes by increasing motivation and cognitive engagement. Games also include different types of scaffolds, including motivational, cognitive and metacognitive support, which contribute to the overall experience (Morris et al. 2013, p. 88). In addition, the implementation of video games in other fields of education, such as mathematics, has reportedly increased students' academic achievement (Hieftje et al. 2017, p. 23).

According to Hieftje et al. (2017, p. 25), gamified learning experiences have been shown to be more effective than traditional practices. Use of video games helps students improve their metacognitive abilities by increasing their metacognitive behaviour and problem-solving skills (Chatzipanteli et al. 2014, p. 98). Furthermore, the design of video games influences players' metacognitive knowledge and learning behaviours (Drummond & Sauer 2015, p. 103).

More realistic simulations are considered to be 'transfer-appropriate' because they allow players to use the knowledge gained through gameplay to think about real-world analogues (Holbert & Wilensky 2014, p. 76). For the same reason, video games can be used to improve the application of knowledge in practical contexts. Therefore, video games are a highly promising endeavour for SDL and metacognition by ensuring practical

learning experiences are engaging, and present developers can successfully promote cognitive growth and academic success.

## □ Video games and self-directed learning

The concept of SDL emphasises the active role of learners in assuming responsibility for their learning journey. In this concept, individuals define their own learning goals, determine the resources needed to achieve those goals and decision-making actions they will take to reach such goals. Video games have become unique learning environments that embrace the concept of SDL. They offer a high level of agency, choice and direction to the players, who are mandated to determine how to navigate and learn from the experiences (Tokac et al. 2019, p. 70).

The relationship between video games and SDL is symbiotic. Video games enable players to undertake directed exploration and decision-making that are crucial elements of SDL. Through a game, an individual determines learning objectives, formulates strategies and navigates various environments, which is autonomous learning by essence. Moreover, video games are associated with the development of problems that players determine how to solve, and, in the process, they develop various other regulatory skills needed for self-directed learning (Gillern & Stufft 2022, p. 55).

Video games also support autonomy through the provision of a competence-centred learning environment. By permitting players to select, explore and experience the consequences of choices, video games afford players a level of control over their learning experiences. The autonomy motivates the learners to remain engaged and, consequently, take responsibility for their learning outcomes (Bunt & Bunt 2022, p. 43).

In addition to autonomy, video games are integral in enhancing metacognitive abilities, which are key to effective SDL. Metacognition is one's ability to regulate thoughts, and therefore, it is the process that directs learning by planning, executing and assessing the actions during video game plays. Players make choices that are in parallel with learning experiences. Hence, by reflecting on the gaming experience, an individual can enhance their metacognitive skills, including goal setting, strategic planning and self-evaluation, which are the vows of SDL (Marlatt 2018, p. 60).

Furthermore, video games present a learning environment where learners can engage in self-regulated learning practices. The fact that a player has the power to choose the path to pursue during the play, the pace at the rung and the opportunity to track achievements promote independence (Betts & Rothschild 2020, p. 31). Therefore, the player must

plan the time, set the priority and adjust the strategies to remain on top of the experiences. In this respect, video games promote the acquisition of self-regulatory skills needed for effective SDL (Morris et al. 2013, p. 91).

In summary, video games are powerful platforms that enhance SDL. They foster autonomy, develop metacognition and cultivate self-regulatory skills that are critical in enabling learners to take charge of their learning experience and achieve the desired educational goals (Gillern & Stufft 2022, p. 58).

## □ **Autonomy and choice in video games**

When exploring the autonomy and choice used in video games, it is helpful to consult the existing literature on video games' relationship to SDL. There are a number of studies that may be used to gain insights into how the autonomy and choice factor promoted by video games is aligned with SDL.

One of the possible references to use is a study by Ng, Liu and Wang (2018, p. 3) that explores the role of autonomy in video games and its impact on players' decision-making and engagement. This study may help to better understand how video games give players the autonomy to make decisions that affect their gameplay, which is a principle of SDL.

Another relevant study is the one by Ninghardjanti and Dirgatama (2021, p. 49) that provides insight into the relationship between video game mechanics of limitless autonomy and the self-regulation component of SDL. This study may clarify the idea of how players' decisions in video games are intertwined with self-regulatory efforts that are also entrenched in SDL.

The reading by Demouy et al. (2016, p. 12) about learner ownership may help to better comprehend the concept of autonomy as a decision-making factor in video games. This study may clarify how freedom to explore and choose in a video game promotes the sense of ownership and responsibility present in SDL.

Video games offer players a high degree of autonomy, allowing them to make decisions and choices that directly impact the outcome of the game (Ng et al. 2018, p. 3). This autonomy resonates with the SDL principle of self-regulation (Ninghardjanti & Dirgatama 2021, p. 49). Players decide which tasks to undertake, how to approach challenges and the pace at which they progress, all of which are central to SDL (Ninghardjanti & Dirgatama 2021, p. 50). This freedom to explore and make choices contributes to a sense of ownership over the learning process (Demouy et al. 2016, p. 12).

## □ Feedback and reflection

Feedback and reflection are fundamental components of any learning process, and video games offer novel ways to incorporate these aspects and promote SDL. Video games primarily follow a set of feedback mechanisms that inform players on performance, and this aspect is vital for SDL (Bejjanki et al. 2014, p. 22). For example, players, through continuous feedback, can determine what works and what does not, optimising and maximising their potential (Gee 2007, p. 45). The feedback given to players informs them of their performance levels and compels them to reflect on their actions and decisions. Additionally, players are given feedback on their plots of actions in the game, which compels them to think critically and contemplate better paths (Bunt & Bunt 2022, p. 43).

This process of receiving feedback, reflecting on the feedback and adjusting one's actions mirrors the elements of SDL and metacognition. The mechanism of feedback also stimulates metacognitive awareness and thought, which entails contemplating one's anticipation processes and judging one's work (Berard et al., 2015, p. 18). By using feedback mechanisms to adjust strategies on how they execute objectives and missions in a game, the player establishes a learning and reflective loop.

This system is not only educationally productive but also promotes a growth mindset, which involves the perspective that errors are sometimes necessary for improvement and another chance (Gillern 2016, p. 34). This iterative cycle not only reinforces learning but also cultivates a growth mindset, encouraging players to persist in the face of challenges and view mistakes as opportunities for growth and learning (Xiang et al. 2023, p. 56).

## □ Problem solving and critical thinking

Video games develop problem solving and critical thinking by promoting cognitive skills. During the interaction with games, people are often made to solve complex tasks, which develops cognitive functions that promote SDL and metacognition (Choi et al. 2020, p. 101). Problem solving and critical thinking within video games often occur as a result of the active assessment of the playing field, the subsequent analysis of the information received and the application of the result (Przybylski, Rigby & Ryan 2010, p. 78). At the same time, the person's actions are controlled by the principles of self-direction, when a person chooses the paths of a solution independently and acts on an informed basis (Green & Bavelier 2012, p. 66).

Problem solving and critical thinking in video games are successful methods of developing such abilities as they involve active problem

solving with the frequent need to evaluate options. Moreover, most of the tasks of this level also include the practice of metacognitive processes. Metacognition is the process of thinking about one's cognitive activity and decision-making, significant for proper problem solving and critical thinking (Gustian et al. 2023, p. 45). In the video game scenarios, players are often asked to understand their experience of thinking, to assess the expediency of the chosen strategy and, depending on the feedback, to again solve the task (Pamungkas, Aminah & Nurosyid 2018, p. 84). As a result, a player not only practises the ability to think and make informed decisions but also develops a skill that allows representing mental processes.

In addition to the development of such skills, problem solving and critical thinking also develop analytical reasoning, logical thinking and decision-making. Players are frequently tasked with analysing complex situations, assessing multiple options and making informed choices to advance in the game (Bonner et al. 2022, p. 109). This process enhances their problem-solving abilities within the game context and equips them with transferable skills applicable to real-world scenarios.

## ■ Video games and metacognition

### ■ The metacognitive cycle

Metacognition involves an individual's awareness and control over their cognitive processes, encompassing the ability to plan, monitor, evaluate and regulate one's learning (Zion & Cohen 2021, p. 5). Video games provide a rich environment for engaging in the metacognitive cycle (Vedechkina & Borgonovi 2021, p. 2). Players constantly assess their progress, identify challenges, devise strategies and adapt based on the results, mirroring the metacognitive loop (Almufareh 2021, p. 718).

### ■ Reflection and strategy development

Video games encourage players to reflect on their in-game actions and outcomes (Tartar et al. 2021, p. 3). This reflective process aligns with metacognition's core function of self-monitoring and self-regulation (Vaughan 2013, p. 815). Through this reflection, players develop strategies and tactics to enhance their performance (Musa et al. 2021, p. 182). For example, in real-time strategy games, players continuously assess their resource management and adapt their strategies as the game unfolds, highlighting their metacognitive engagement (Vedechkina & Borgonovi 2021, p. 4).

## ■ Transfer of metacognitive skills

An intriguing aspect of video games is the potential for the transfer of metacognitive skills to real-world contexts (Voiskounsky et al. 2017, p. 146). The metacognitive abilities honed in video games, such as planning, monitoring and adapting strategies, can be applied to various educational and life situations (Vedechkina & Borgonovi 2021, p. 5). Research suggests that individuals who engage in video gaming demonstrate improved metacognitive skills, impacting their academic performance and problem-solving abilities (Tartar et al. 2021, p. 5).

The following section outlines the theoretical framework of the study.

## ■ Theoretical framework

### ■ Situated learning and cognitive apprenticeship

Video games can be viewed through the lens of situated learning and cognitive apprenticeship theories (Binder et al. 2015, p. 5). These theories emphasise learning in authentic contexts and through apprenticeships with experts (Newton & Ashby 2019, p. 6). Video games often provide a virtual environment where players engage in authentic tasks, learn from trial and error, and receive guidance from in-game characters or tutorials (Lunney, Hyndman & Kevitt 2011, p. 56). Players gradually become experts in the game, mirroring the cognitive apprenticeship process (Tartar et al. 2021, p. 11).

### ■ Flow theory

Csikszentmihalyi's flow theory posits that individuals experience a state of optimal engagement when the challenges of an activity match their skills (Mark, Zaiton & Azizan 2018, p. 12). Video games are designed to create this state of flow, where players are fully absorbed and lose track of time (Hintze & Yee 2021, p. 793). This concept relates to metacognition as players continually adjust their strategies to maintain this balance, which requires monitoring and reflection (Vaughan 2013, p. 819).

### ■ Constructivist learning

Constructivist learning theory argues that learners actively construct knowledge through experience and reflection (Soliman, Salman & Din 2022, p. 2). Video games align with this theory as players actively build their knowledge by solving in-game challenges (Hajian 2019, p. 93). They draw

upon their prior knowledge, adapt to new situations and refine their cognitive strategies, emphasising metacognitive processes (Ghazali 2020, p. 115).

While each of the above theories provides deep and valuable insights, they also have significant limitations. However, the gaps in one can be adequately filled by the integration with the rest theories. Self-directed learning lays the foundation, emphasising the autonomous nature of the learner (Knowles 1975, p. 18). Game-based learning focuses on motivation and ensures that the learner is entertained (Plass et al. 2010, p. 105). Situated Learning and Cognitive Apprenticeship offer solutions for contextual and social learning, making the knowledge and skills acquired via SDL and GBL applicable (Collins, Brown & Newman 1989, p. 454; Lave & Wenger 1991, p. 31). Flow Theory assures that the learner is always in a seemingly impossible position (Csikszentmihalyi 1990, p. 71), while Constructivist Learning underlines the importance of reflection (Piaget 1954, p. 26). This framework enables the integration of three theories that have been shown to have gaps when used separately to form a holistic model, which can be more effective than traditional instructional methods. By examining how these theories interact and support each other, more effective strategies for GBL and SDL in higher education can be developed (Lunney et al. 2011, p. 58; Shaffer et al. 2005, p. 107).

## ■ Identifying literature gaps

Even though the theories behind GBL and SDL are well researched, there are no significant studies that consider the integration of the theories in higher education. Also, there are few studies on the criteria that the games have to meet to promote SDL effectively (Plass et al. 2010, p. 108). This study considers the role of video games in enhancing SDL among third-year Bachelor of Education students and developing the criteria for choosing and implementing GBL (Lunney et al. 2011, p. 59; Shaffer et al. 2005, p. 109).

## ■ Challenges and concerns

While video games offer numerous opportunities for SDL and metacognition, there are also concerns (Barandiarán, Di Paolo & Rohde 2019, p. 105). Some scholars argue that excessive gaming may lead to negative consequences, such as addiction or decreased engagement in traditional learning activities (Zhu et al. 2021, p. 4). Therefore, it is important to strike a balance between video GBL and other educational methods (Lunney et al. 2011, p. 56).

Video games, through their design features, align with the principles of SDL and provide opportunities for metacognitive engagement (Lunney et al. 2011, p. 57). The autonomy, feedback mechanisms and problem-solving challenges in video games foster self-regulation, reflection and cognitive strategy development (Yan et al. 2021, p. 9). Theoretical frameworks such as situated learning, cognitive apprenticeship, flow theory and constructivist learning help us understand how video games create a conducive environment for learning (Herrero et al. 2014, p. 27).

However, the integration of video games into educational contexts should be done thoughtfully, considering the potential challenges and concerns, such as addiction and reduced engagement in traditional learning (Vahlo, Tuuri & Välisalo 2022, p. 7). Future research should continue to explore the mechanisms through which video games promote SDL and metacognition and investigate the most effective ways to harness their potential for educational purposes (Verhagen et al. 2019, p. 9).

In summary, the evolving landscape of digital technologies and the growing influence of video games in education raise significant questions about how to harness their potential for SDL and metacognition. This theoretical literature review provides a foundation for further exploration and understanding of the multifaceted relationship between video games, learning and cognition.

The following section outlines the methodology used in this study.

## ■ Research design and methodology

### ■ Research design

We decided to take an interpretative position and selected the one or another form of qualitative research. Phenomenology, as a method of qualitative research, focuses on the perception of a certain area of human experience through the commonality of people's experiences and is mainly aimed at describing the phenomenon under study, 'Phenomenology is a method for collecting this fresh description' (Creswell & Poth 2016, p. 10). Open-ended interviews with people who are familiar with Alzheimer's – from first-hand experience – were conducted, and competitive questions, 'What have your perceptions of this phenomenon been like?' and 'How have your proximity or location handled these phenomena for you?' (Moustakas 1994, p. 103) were used. In addition to this, informational sources were supplemented by documents, observations and works of art. All these data were analysed, re-read and sorted by matching words and topics. Related ones were combined into logical groups or categories with the help of deductive content analysis method (Creswell & Poth 2016, p. 12).

Generally, these actions led to the generation of a comprehensive, or universal, understanding of the event, situation or phenomenon.

## ■ Sampling strategy

The scope of this investigation was all Bachelor of Education students who have a major in History in South Africa. Because of logistical restrictions, the case population has been limited to third-year Bachelor of Education students with History as a major at a South African university. A non-probability, convenient, purposive sample of 30 third-year Bachelor of Education students from North-West University's Vaal Triangle Campus was used. Purposeful sampling means inviting individuals for a specific reason (De Vos & Strydom 2011, p. 473; Leedy & Ormrod 2015, p. 183). For that aim, the first author purposely chose third-year Bachelor of Education History students because the selected video games are based on historical issues. Convenience sampling was also a factor because all participants were from the same institution as the author, all studying History for Education, presented by the researcher. Ten third-year students were selected with the goal of determining how far they are on the road to becoming self-directed, reflective students, consequently devising a plan on how to advance the opportunity to teach these skills in their subsequent years left in university before admitting them into the teaching profession. Clips and explanations of several historical and history-for-education-adjacent video games were used to demonstrate these to the subject. The clips mentioned featured actual gaming and expository video, as well as several excerpts from the game stream.

## ■ Data collection instruments

At the end of the video game intervention, the first author conducted one-on-one, semi-structured interviews that were based on open-ended questions. Semi-structured interviews allow open-ended, close-ended question forms and provide for variation in the formulations of the questions asked (Agustianingsih & Mahmudi 2019, p. 2). The interviewer utilises questioning designed to evoke context and probing where necessary for a more in-depth discussion (Agustianingsih & Mahmudi 2019, p. 3). Interviews were continued for 30 min or stopped when no new information was being gathered. Interviews were conducted over Zoom, at a time suitable for students.

## ■ Data analysis

The analysis and interpretation of the gathered data were based on the research questions. Thematic analysis is a technique widely used for

developing, examining, and finally checking themes or patterns within data. It is a versatile and transdisciplinary approach that allows for a comprehensive explanation of complex phenomena and the integration of disparate perspectives and broader data sets (Braun & Clarke 2006).

## ■ Ethical considerations

This study is approved by the Education Sciences Research Ethics Committee (EduREC) at North-West University, Potchefstroom, South Africa. The study was approved for ethics under the number NWU-00259-22-A2. Informed written consent was obtained from all study participants. All of the data collected were anonymised and participants were given unique identifiers in order to protect privacy. The data were kept securely and were only available to the researchers, so that participants' personal information would not be revealed. It is to be noted that no animal research was involved in the study.

## ■ Findings

The analysis and interpretation of the data were guided by the research questions. The authors used thematic analysis, a qualitative research approach, to identify, analyse and interpret patterns within the data set (Braun & Clarke 2006). This method is versatile and adaptive, making it suitable for investigating intricate phenomena and encompassing a wide range of viewpoints. The following section reports the data analysis findings and interpretations together.

## ■ Factors influencing initial impressions

Participants were asked what factors influenced their initial impression of the video games.

Several participants mentioned nostalgia and previous exposure to games as influential. One participant remarked, 'I grew up playing this game on my phone, seeing it brought back memories' (student, gender undisclosed, 22 October 2022). Others noted the appeal of historical themes and accurate depictions, with comments like 'I like the graphics and the ancient techniques they used' (student, gender undisclosed, 22 October 2022) and 'seeing the graphics and the accuracy of historical intro' (student, gender undisclosed, 22 October 2022).

The storytelling approach in the games also played a significant role. A participant noted, 'The narrator at the beginning makes one want to know more about the storyline of the game' (student, gender undisclosed,

22 October 2022), while another said, 'I am impressed by the way the game explains the great war by not only sticking to the war but incorporating a love story to keep players intrigued' (student, gender undisclosed, 22 October 2022).

Visuals and art style were frequently mentioned. For instance, one participant appreciated the 'comic book art style of the graphics that sort of makes the content less daunting' (student, gender undisclosed, 22 October 2022).

Participants also expressed interest in the strategic and educational potential of the games. For example, a participant said, 'The strategy aspect of the game influenced my initial impression' (student, gender undisclosed, 22 October 2022), and another noted, 'The graphics and the strategic aspect' (student, gender undisclosed, 22 October 2022).

## ■ Motivation to learn more

Participants were asked if the game motivated them to learn more about the subject.

Many participants felt that the games made historical content come alive. One stated:

'Yes. Because the game makes you as the player experience how it was during the time of the events of the game, so it will make the theory content come to reality.' (student, gender undisclosed, 22 October 2022).

Another added, 'Yes ... this game is based on real historical events that happened long ago, so playing it will help you understand how different events unfolded' (student, gender undisclosed, 22 October 2022).

The emotional engagement and different perspectives offered by the games also motivated participants. One participant noted, 'Yes it does. The game gives an account of the subject of the war from the perspective of five characters. It's always interesting to see different perspectives' (student, gender undisclosed, 22 October 2022).

However, some participants were more critical. For example, one participant said, 'No, because it doesn't connect to any historical context' (student, gender undisclosed, 22 October 2022), highlighting the importance of relevance to the curriculum.

## ■ Perception of challenge

Participants were asked if the game looked challenging to them.

Responses varied, with some participants finding the games challenging because of their complexity and need for strategic thinking. For example, one participant stated, 'Yes, because you have to go through different stages and challenges in order to be granted the power of being a king' (student, gender undisclosed, 22 October 2022). Another noted, 'Yes it does. The strategising of the dynasty leaders to rise up in ranks requires critical thinking and would make the game an interesting challenge' (student, gender undisclosed, 22 October 2022).

Others found the games less challenging, citing clear instructions and user-friendly design. One participant mentioned, 'No, because the instructions are understandable and the layout is not complicated' (student, gender undisclosed, 22 October 2022).

## ■ Educational use

Participants were asked if they could teach with the game and how.

Many participants saw potential for educational use, particularly in teaching historical content and strategic thinking. One participant said, 'Yes. Use the game to test learners' understanding, after teaching them about the history of the middle ages' (student, gender undisclosed, 22 October 2022). Another noted, 'Yes, I would ask learners to play it then write their emotion based on the game and reflect on some historical events' (student, gender undisclosed, 22 October 2022).

Some participants highlighted the visual and engaging nature of the games as beneficial for teaching. For instance, one participant stated, 'Yes, learners will have to state their views about this game, this will help them to be able to analyse sources' (student, gender undisclosed, 22 October 2022).

However, there were concerns about the appropriateness of certain games for educational purposes. One participant noted, 'No, learners will learn violence' (student, gender undisclosed, 22 October 2022), emphasising the need for careful selection of game content.

## ■ Discussion

### ■ Theme 1: Factors that could aid educators in selecting apposite gaming media for history education

Examining the many aspects that impact participants' perceptions of the shown games yields significant information for educators when choosing

gaming media for history instruction. The intersection of SDL, GBL and metacognition is exemplified by the prominent role of childhood nostalgia, player choice, historical knowledge, and thematic interests in the context of Assassin's Creed (Liu, Choi & Li 2021, p. 4; Paschoalino et al. 2019, p. 115; Tay & Lim 2008, p. 521; Van Lippevelde et al. 2016, p. 3). One participant remarked about how he had played the game before. Valiant Hearts, The Great War garnered acclaim for its narrative prowess and ability to evoke emotional involvement, so indicating the prospect of narrative-focused serious digital games and the cultivation of metacognitive processes (Nettley 2013, p. 53; Sarkies et al. 2020, p. 5; Vahlo et al. 2022, p. 8). A participant remarked that the storytelling approach appealed to him. The participants in the study found that the narrative delivery and emotional aspects of Crusader Kings III were effective in evoking a response, highlighting the role of narrative and emotional links in influencing metacognitive processes (Li et al. 2021, p. 139; Lunney et al. 2011, p. 57). A participant liked how the story was delivered. The popularity of Ghost of Tsushima was primarily based on the strong affinity that players had for Samurai-themed material, visually stunning visuals and engaging action sequences. These aspects of the game resonated with the ideas of interest-driven SDL and GBL (Jaftha, Pinto & Chircop 2020, p. 73; Ninghardjanti & Dirgatama 2021, p. 66; Vedeckina & Borgonovi 2021, p. 20). A participant noted his love for anything related to Samurai. The appreciation of historical eras, strategic components and possible educational applications in Total War, Rome II highlights the connection between engagement, SDL and metacognition (Coroller & Flinois 2023, p. 7; Knowles 1975, p. 18; Tay & Lim 2008, p. 521; Thu & Vien 2022, p. 162). A participant appreciated the strategic element of the game. In conclusion, the appeal of Age of Empires III can be attributed to its incorporation of an empire concept, depiction of Africa, visual realism and nostalgic elements. These aspects underscore the importance of culturally diverse and personally meaningful content in fostering metacognitive engagement (Azizi, Fielding & Abel 2022, p. 14; Kuss, Griffiths & Pontes 2017, p. 103; Phuong et al. 2023, p. 164). A participant mentioned content-related factors such as, 'The fact that the game is about Empires' (student, gender undisclosed, 22 October 2022). The aforementioned aspects combined illustrate the intricate relationship between SDL, GBL and metacognition in influencing individuals' interpretations of historical video games. These findings provide educators with useful perspectives on how to effectively integrate such media into history instruction.

## ■ Theme 2: Incentives and drives as motivation to engage with the history video games

Participants noted for Assassin's Creed how the game brought history to life, connecting with SDL concepts of personal participation and

self-regulation (Chen et al. 2021, p. 8; Vasalou, Ingram & Khaled 2012, p. 125). A participant stated that games can make history come alive, Valiant Hearts, The Great War piqued participants' interest with its depiction of World War I, stressing an intrinsic desire for historical research and engaging viewpoints that develop metacognition (Du Toit-Brits 2022, p. 58; Kessner & Harris 2022, p. 115; Makri, Vlachopoulos & Martina 2021, p. 28). A participant noted that she wanted to know more. The representation of historical events and kingdoms in Crusader Kings III piqued people's interest, showing possible support for SDL and GBL via metacognitive reflection and historical content exploration (Lunney et al. 2011, p. 58; Mol & Politopoulos 2021, p. 44; Ninghardjanti & Dirgatama 2021, p. 67). A participant was intrigued by the drama present in the game. The various reactions of the Ghost of Tsushima underlined the role of individual interests on motivation, highlighting the need of balancing fun and instructional material in GBL (Aktaş & Sancar 2021, p. 346; Lunney et al. 2011, p. 59; Rebah & Slama 2019, p. 131). A participant was more critical, saying, 'No Because it doesn't connect to any historical context' (student, gender undisclosed, 22 October 2022). Total War, Rome II's narrative-driven engagement and players' varied emotions highlight the importance of individual interests and motivation in GBL, which aligns with SDL principles (Chen et al. 2021, p. 8; Christofi, Hadjipanayi & Michael-Grigoriou 2022, p. 2; Vedeckina & Borgonovi 2021, p. 21). A participant was motivated by all the features in the game, stating, 'Yes it does because it incorporates features of trade relations, tactical battles and civilisation management' (student, gender undisclosed, 22 October 2022). Age of Empires III highlighted the ability of games to enable SDL by engaging learners with particular historical knowledge while also providing critical viewpoints on the game's educational usefulness (Mahayanti et al. 2020, p. 37; Tay & Lim 2008, p. 523, 524). A participant was more negative, saying that only social elements could be learned, explaining, 'No, there is no real historical aspect that can be learned, except for the way of life' (student, gender undisclosed, 22 October 2022). These results show the complex interaction between video game elements, human motivations and the potential for SDL and GBL in history teaching.

The final question asked was, Question 3, Could you teach with this game? If so, how?

### ■ Theme 3: Considerations for the appropriateness of the presented games for game-based learning

The viewpoints of participants on the possible use of historical video games for education indicate a variety of ideas and concerns. Participants in Assassin's Creed acknowledged the significance of the game in assessing students' comprehension after conventional education, stressing

self-regulation and critical thinking (Coroller & Flinois 2023, p. 8; Knowles 1975, p. 18; Lim et al. 2023, p. 12; R uth & Kaspar 2021, p. 11). A participant stated, 'Yes. Use the game to test students understanding, after teaching them about the history of the middle ages' (student, gender undisclosed, 22 October 2022). Valiant Hearts got favourable reviews as a tool for teaching trench conditions, suggesting the game's ability to improve knowledge acquisition and source analysis (Morris et al. 2013, p. 607; Robillos 2023, p. 553). A participant stated, 'Yes I would. I would teach them how the soldiers used to build the trenches to fight in the war and how they were useful they were' (student, gender undisclosed, 22 October 2022). Crusader Kings III was deemed appropriate for teaching kingdoms, war tactics, politics and the Middle Ages, in line with SDL concepts of student agency and metacognitive reflection (Haruna et al. 2018, p. online; Knowles 1975, p. 18; Mahboobin & Clark 2020, p. 32). A participant noted the usefulness of the game to teach about monarchies, illuminating, 'When giving a lesson about a monarchy the students could play the game and by the end will have insight about monarchies' (student, gender undisclosed, 22 October 2022). The Ghost of Tsushima sparked discussions about comparing historical figures, teaching Japanese history and addressing colonisation, as well as revealing concerns about curriculum fit and workload, emphasising the need for thoughtful integration of GBL into the curriculum (Kessner & Harris 2022, p. 120; Li et al. 2021; Yusof & Shahrill 2021, p. 25). A participant disagreed, citing the curriculum as a stumbling block, saying, 'No, I don't see how this would fit into the curriculum and workload' (student, gender undisclosed, 22 October 2022). Total War, Rome II was seen as a teaching tool for ancient Roman culture, trade connections and military methods, with the ability to pique students' interest while raising concerns about violent material (Conrady 2015, p. 132; Gordillo et al. 2021a, p. 8485; Knowles 1975, p. 18). A participant noted the use of the game for teaching how societies lived. Age of Empires III sparked debate over whether the game's violence rendered it unsuitable for educational purposes, demonstrating the nuanced considerations required for effective GBL implementation (Flavell 1976, p. 11; Steinkuehler & Duncan 2008, p. 533). Another participant agreed, stating, 'Yes I can actually teach African history to my student and teach on how they fought' (student, gender undisclosed, 22 October 2022). Overall, our findings emphasise the necessity of connecting video games with educational aims, taking into account metacognitive processes and deliberately incorporating GBL into history instruction.

## ■ Conclusion

Having introduced the six historically themed and history-for-education adjacent video game trailers, participants showed varied responses based

on the snippets. In the first instance, the reactions to each snippet for each of the games were largely positive. Game 1, *Assassin's Creed*, seemed to elicit near-perfect satisfaction, whereas the response to snippets for Game 5, *Total War, Rome II*, showed the most mixed reaction. Nonetheless, satisfaction is not enough to qualify whether the media is suitable for education. It is in this regard that the following results of responses to in-depth questioning are offered.

On the one hand are the factors affecting the impression of their videos. They include nostalgia for Game 1, genre for Games 1, 3 and 6; fidelity for Games 1 and 5; theme for Games 1 and 6 (but based on differences); story for Games 2 and 5; framing or content delivery for Games 2 and 6; emotional response to Game 2; aesthetics and art style for Games 2 and 5; narrative elements for Game 3; familiarity with content elements or setting for Games 4 and 6; game aim or focus for Games 5 and 6; and relationship with daily activities for Game 5. This information may be very useful for educators to select eligible gaming media for educational use, especially for history courses.

Notably, reading the first-hand responses revealed patterns of motivation to participate and view the snippets. Such dimensions included immersion for Games 1 and 3; accuracy for Games 1 and 4; appropriateness for Games 1 and 6; content for Games 1, 3 and 5; narratology for Games 2 and 6; game aim or focus for Games 2 and 6; clarity from content for Games 2 and 6; level of control from Game 3; potential for learning from Games 3 and 6; familiarity with content from Game 4; user relevance for Games 4 and 6; intrigue for Game 5; game appeal through elements for Games 3 and 5; and depth as either holistic or shallow from the factualness of Game 5. The motivational dimensions need further analysis to assess their prioritising in the selection of appropriate GBL for education and start the development of a framework for such choice.

Conversely, the challenging elements concern the suitability of choice for GBL. From the participant responses, puzzle-solving is from Game 1; critical thinking from Games 1, 4 and 6; difficulty from Games 1 and 4; input evaluation from Games 1 and 6; unpredictability from Games 2 and 5; clutter from Game 2; progression from Game 3; information provision in terms of depth from Games 3, 5 and 6; strategy from Game 3; interface and experience from Games 3, 5 and 6; skill requirement from Games 4 and 5; genre from Game 4; ergonomics from Games 5 and 6; and points of reference for background knowledge from Game 6. These aspects limit access to the chosen media and may be investigated further.

On the other hand, the considerations about the appropriateness of the games are Game 1 through the emotional affect; Games 1 and 5 for relatability; Games 1, 3 and 6 for majorly varying authenticity including

violence and realism; utility or purpose served from Games 1, 5 and 6; analytic value for Games 2 and 3; salience for Games 2 and 6; depth for Game 3; auxiliaries or other transferable skills or topics for Game 3; Games 4 and 6 for curriculum fit; arousal or curiosity for Game 5; and overlap among historiographies for Game 6. These dimensions offer a checklist for evaluating educational value for GBL choice.

In summary, this group of third-year students in the Bachelor of Education with a History major demonstrated a nuanced understanding and engagement of GBL. The students recognised that in an SDL environment, such as GBL, it was their responsibility to select learning activities that would stimulate engagement and self-regulation. In this regard, game selection was strategic, involving the importance of selecting content that supports educational objectives and choice of content that may elicit strong reactions, especially when violence is involved. Video games were seen as dynamic, making learning more enjoyable and engaging. Furthermore, the interactivity of video games facilitated SDL dramatically for the participants enrolled in the third year of the Bachelor of Education programme. This student group was encouraged to set learning goals and think critically about the historical information provided. Thus, by selecting content for GBL carefully, GBL can be utilised in history courses to develop a learning environment that promotes students' active role and SDL.

# Modelling metacognitive monitoring skills and self-regulated learning: Teacher experiences in selected secondary schools<sup>3</sup>

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## ■ Abstract

The province of KwaZulu-Natal (KZN) in South Africa exhibits a wide range of cultural and contextual elements that have an impact on students' learning and academic performance in schools during a period of educational transition in South Africa. Contrary to its slogan, *masisukume*

3. This chapter represents a substantial reworking (more than 50%) of Ragvan (2022).

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*sakhe* ('let us rise and build'), KZN has been battling to achieve excellence in education. The authors of this chapter propose that improving learners' self-regulated learning skills could lower the high failure rates in that area, equip learners with 21st-century skills and better prepare them for success in their post-secondary employment and personal life. When confronted with situations that are beyond their capacities, learners who have developed self-regulated learning skills can control their emotions, behaviour and cognition. The purpose of this chapter is to explore teachers' views, in higher quintile four and five schools in the iLembe area of KZN, of their confidence and teaching strategies to model and develop metacognitive monitoring as a self-regulated learning skill in students. The study applies Zimmerman and Moylan's (2009) model of self-regulated learning as a theoretical and conceptual lens that unmasks how secondary school teachers (do or do not) model metacognitive monitoring to develop metacognitive learning skills in learners. In this qualitative research, a basic interpretive qualitative study is positioned within an interpretivist paradigm. Sixteen secondary school teachers were purposively selected based on their understanding of how they employ metacognitive monitoring to develop metacognitive learning skills in their students. This study employed content analysis and a thematic approach to analyse the data, aiming to derive coherent meaning and enhance comprehension of the information within the context of the research objectives. The study's findings indicate that most participants in the study felt confident that they possessed the necessary pedagogical content knowledge to develop metacognitive monitoring as a self-regulated learning skill. However, the findings also indicate a need for professional development to increase teachers' knowledge and skills for learner-centred teaching approaches towards improved development of their learners' metacognitive and self-regulated learning skills. This chapter highlights why modelling and growth of metacognitive and self-regulated learning skills depend so much on teachers' motivation, self-confidence and optimism, and why metacognitive, self-regulated learning and self-directed learning (SDL) skills should be emphasised by higher education institutions and teacher preparation programmes.

## ■ Introduction

The 21st century advancements, particularly in science and technology, have swiftly reshaped learning, work and lifestyles (Schwab 2016, p. 9). The dynamic demands of this changing world, characterised by technology advancements in education, call for an ongoing improvement in teaching approaches across the globe. Teaching strategies that foster students' abilities to think critically, solve problems, work with others, communicate,

become lifelong learners and use digital literacy are becoming more and more important for success in the 21st century, in the classroom and beyond (Coşanay & Karalı 2022, p. 434).

Students who acquire and master these abilities are better prepared to succeed academically as well as to take advantage of the opportunities and challenges brought about by the quickly evolving global landscape. Academic curricula are adapted to include self-regulated learning skills to cultivate students' abilities so that they can effectively navigate and contribute to a society functioning within the complexities of the 21st century (Coşanay & Karalı 2022, p. 434). The authors of this chapter agree with Van Wyk (2017, p. 274), Moseki and Schulze (2019, p. S1) and Beach, Anderson, Jacovidis, and Chadwick (2020, pp. 11-12) who also state that increasing learners' metacognitive monitoring and self-regulated learning skills, which can be done in any educational setting, could improve their academic success that will help them succeed personally as well as in their post-secondary education and careers. These skills will further equip learners with 21st-century skills that will prepare them for success in their post-secondary school studies and employment as well as their personal lives. When confronted with situations that are beyond their capacities, students who have developed these metacognitive skills have been shown to be able to control their emotions, behaviour and cognition to achieve academic and other forms of success (Beach et al. 2020, p. 11; Harding et al. 2018, p. 6). Self-regulated students assess their motivation and ability to achieve goals using their metacognitive knowledge. They consider gaps in their prior knowledge, and they plan their learning journeys strategically (Peel 2017, p. 72). Moreover, they apply metacognitive monitoring by informally and mentally keeping track of their progress and performance results (Zimmerman & Moylan 2009, p. 303). This suggests that a person's metacognitive skills affect their ability to become self-regulated and ultimately self-directed learners (Quigley, Muijs & Stringer 2018, p. 9). Therefore, to increase learners' motivation, self-awareness and critical thinking skills, they must strengthen their metacognitive monitoring and self-regulated learning capacities. According to Zimmerman (2010, p. 13), all self-regulated learning skills – which include metacognitive monitoring – can be taught by teachers.

## ■ Problem statement

Despite the advantages of metacognition and self-regulated learning skills for academic performance, teachers' knowledge, abilities and confidence to develop these skills is a pressing question against the background of the poor National Senior Certificate (NSC) results of many students.

The failure rates and poor academic achievements of South African students pursuing the NSC stand in stark contrast to these rapid improvements and are a cause of concern for the education sector. Evidence of low-performing schools in KwaZulu-Natal (KZN) is given as follows: the total number of secondary schools in KZN is 1765, and of these schools, five schools received 0% to 19% pass rate, 20 schools attained 20% to 39.9% pass rate and 113 schools received 40% to 59.9% pass rate in the NSC examination in the year 2022 (Department of Basic Education 2022, p. 5). Only 21 secondary schools in KZN out of 1765 schools achieved 100% pass rate from 2017 to 2021 (Department of Basic Education 2022, p. 10). The results of the NSC examination indicate KZN to be one of the worst-performing provinces in South Africa. Against this background, teachers in these areas face even greater difficulties in terms of delivering high-performing, academically successful learners.

Delfino and Persico (2018, p. 841) report that there are insufficient teacher training workshops to increase awareness of the need to enhance students' and teachers' self-regulated learning skills as 21st-century skills. There are not enough options for teachers to attend professional development courses that can empower them with theoretical and practical knowledge to teach students how to learn. The authors also note that the teachers in their study reported feeling demoralised by environmental, cultural and societal issues affecting their school and its surroundings, such as aggressive students, poor housing, a lack of basic supplies, adolescent pregnancies, drug abuse and unmotivated pupils. These and potentially many other factors have been found to influence teachers' motivation to foster and improve students' self-regulated learning abilities (Baloyi 2020, p. 25).

Another considerable challenge unique to linguistically and culturally diverse countries is that of the language of instruction. The use of English as the language of instruction can hinder the development of metacognitive monitoring and self-regulated learning skills for students who are not proficient in English. This language issue is exacerbated when both the learner and the teacher struggle with the instructional language. African language speakers who speak English as a second language were found to have a harder time learning the language and comprehending lesson material that is provided in English (Baloyi 2020, p. 26). Another challenge, noted by Ragvan (2022, p. 106) and Dignath (2016, p. 84), is that in many schools, teachers spend little time on supporting self-regulated learning in their teaching approaches because of the limited contact time available with students and departmental pressure to complete the syllabus.

Other personal determinants can also deter teachers from fostering and developing metacognitive and self-regulated learning skills. For example,

some older teachers find it difficult to adapt to changing curricula and new developments in teaching and learning, which differs vastly from the educational system in which they were initially trained and practised for years (Baloyi 2020, p. 25). As another challenge, Askell-Williams, Lawson and Skrzypiec (2012) and Li (2012) (as cited in Beach et al. 2020, p. 12) found that teachers do not have enough time to study and comprehend the best methods for metacognitive learning and different available strategies for ensuring developmentally appropriate teaching. These authors reflect on these difficulties when recommending that teachers require knowledge and training on incorporating metacognition and self-regulated learning skills (including technology) into everyday teaching and learning practices.

Teachers serve as mentors and facilitators for the growth of metacognitive and self-regulated learning skills. Peeters et al. (2014, p. 1964) contend that they ought to cultivate self-motivation and acknowledge that becoming effective facilitators in fostering self-regulated learners necessitates adopting a mindset of lifelong learning and self-regulation. This involves not relying solely on the knowledge acquired during initial teacher preparation. It is appropriate to give due consideration to the human element and contexts in social situations given their individual potential to affect outcomes.

Recent developments in the field of education research show that the most effective teaching practices are those that adapt to the needs of the learners and the context in developing the best practices for promoting self-regulated and metacognition in students. Yet, despite the above needs and concerns, there is a paucity of research pertaining to teachers' confidence and pedagogical content knowledge to develop metacognitive monitoring as a self-regulated learning skill among their students in KZN (Ragvan 2022, p. 6).

## ■ Research questions

Considering the influence of metacognitive monitoring as self-regulated learning skill on academic performance, we were interested to explore whether and, if so, how school teachers develop these skills in their students. In light of this background, the research questions below were stated.

- What do secondary school teachers in quintile-four and quintile-five schools believe about their confidence in fostering self-regulated learning skills in their learners?
- How do they perceive themselves to model metacognitive monitoring skills as a self-regulated learning skill to help students build their own metacognitive monitoring abilities?

## ■ Motivation of the study

Against this background, the authors of this chapter propose that higher education institutions (HEI), education departments and researchers would benefit from a deeper understanding of teachers' beliefs about their confidence in supporting the development of metacognitive monitoring as a self-regulated learning skill, as well as how they model metacognitive monitoring to develop similar skills in their students. This knowledge should guide effective decision-making to support teachers in fostering their students' self-regulated learning and metacognitive skills, which are crucial for improving academic performance.

## ■ Theoretical framework

This study approached self-regulated learning from the lens of Zimmerman and Moylan's (2009) current version of the cyclical phase model. With this approach, the researchers intended to explore how secondary school teachers perceive and how they model metacognitive monitoring as a self-regulated learning skill to develop similar skills in students. Zimmerman and Moylan's model addresses the cognitive, metacognitive, behavioural, motivational and affective aspects that self-regulated learners demonstrate and that teachers should develop with modelling and the use of different teaching strategies.

Self-regulated learning is a broad term that considers how the environment affects learning. The concept involves several psychological influences, including motivation, emotion and metacognition (Beach et al. 2020, p. 3). Lear, Li and Prentice (2016, p. 13) and Saks and Leijen (2013, p. 191) similarly define self-regulated learning as a process in which a person sets new learning goals to acquire new knowledge for academic or personal development. Such a person would therefore take action to obtain learning objectives and personal development. The development of self-regulated learning skills involves metacognitive abilities including self-monitoring, self-thought (thinking about one's own thoughts) and self-motivation.

According to Flavell (1979, p. 906), metacognition is 'knowledge and cognition about cognitive phenomena'. Flavell (1979) posits that metacognition arises from an individual's understanding and deliberate contemplation, or consciousness, of their own cognition and regulation. Metacognitive monitoring involves the process of informally tracking one's performance and learning processes mentally to determine whether one's performance is successful and if the desired outcomes are reached. (Zimmerman & Moylan 2009, p. 303).

Bandura's (1986) Triadic Reciprocal Determinism model forms the basis of Zimmerman and Moylan's (2009) model, which is rooted in social

cognitive theory. The social cognitive theory maintains that metacognitive monitoring is an essential skill for self-regulated learning and asserts that the development and demonstration of self-regulated learning skills are reciprocally influenced by personal, behavioural and environmental determinants within various teaching contexts. Both positive and negative reciprocal effects are possible. Sokha (2024) asserts that people are proactive agents who utilise their own ideas, motives and behaviours to change their social contexts, but their social contexts or environments also shape them by influencing their ideas, motivations, actions and behaviours.

A person's knowledge, past experiences, confidence and attitudes about things are examples of their personality traits that can be considered personal determinants (Koutroubas & Galanakis 2022, p. 317). Bandura (1977, p. 195) avers that individuals' perceptions, motivation and performance are influenced by their self-efficacy perceptions to perform a task. Perceptions of poor capabilities to perform a task will result in low self-efficacy beliefs (Koutroubas & Galanakis 2022, p. 317). In the same vein, Powers et al. (2016, p. 1) state that teachers' self-efficacy, which is connected to their academic success, is a critical personal determinant that influences whether they foster self-regulated learning skills in students. It can thus be inferred that teachers' confidence to develop metacognitive monitoring as a self-regulated learning skill will be influenced by personal variables such as their professional training and development, their familiarity with and competence in using pedagogies to foster metacognitive monitoring as a self-regulated learning skill and other catalysts for their self-efficacy beliefs and motivation in their teaching contexts (Geduld 2019, p. 63). Powers et al. (2016, p. 13) found that teachers' self-efficacy beliefs in their teaching capabilities can be strengthened if they collaborate with high-performing peers from whom they can learn, for example, effective questioning techniques, classroom management strategies or constructivist teaching approaches to enhance student engagement in self-regulated learning (Powers et al. 2016, p. 13).

The above-mentioned personal determinants influence behavioural determinants like teachers' attitudes and commitment towards the implementation of curriculum and new innovations (cf. Sokha 2024). Behavioural determinants refer to skills, practice and self-efficacy (Koutroubas & Galanakis 2022, p. 316). Joseph-Edwards (2019, p. 6) mentions that teachers planned actions such as lesson plans and use of resources to help students achieve learning goals. Ragvan (2022, p. 23) sees teachers' teaching strategies, the type of tasks they select, their motivation strategies and efforts to improve learners' academic achievements as behavioural determinants.

Both personal and behavioural determinants are influenced by environmental determinants that include broader societal contexts and

influences such as colleagues, the work environment (Koutroubas & Galanakis 2022, p. 316), various social and physical factors, such as parents, learning-friendly classrooms, available resources (Ragvan 2022, p. 22), collaboration with peers regarding the teaching and learning processes, the socioeconomic context of a school and the teacher's control of teaching time and workload (Sokha 2024). An example of the interplay between environmental and behavioural determinants can be seen in Govender's (2018, p. S3) study, which states that teachers face persistent curriculum implementation problems (behavioural determinant) because of the amount and quality of professional development they receive from the Department of Basic Education and their schools (environmental determinant). Additionally, teachers report challenges in applying what they have learned in courses (behavioural determinant). Govender (2018, p. S3) suggests collaboration with peers and improved monitoring systems from the Department of Basic Education for support.

According to the revised cyclical stages model of self-regulated learning proposed by Zimmerman and Moylan (2009, p. 300), self-regulated learning skills can be developed over the course of three phases, namely, the forethought phase, the performance or volitional phase, and the self-reflection phase. The forethought phase is the planning stage, which comprises using high self-motivational beliefs to prepare for self-regulated learning. This phase involves analysing a task before learning something new, goal setting and strategic planning. Self-regulated students utilise their metacognitive knowledge to monitor motivation and their set goals both before and during the execution of learning tasks. They create strategic plans to continue learning based on their assessment of their current knowledge as well as their gaps in knowledge (Peel 2017, p. 72). These learners characteristically engage in strategic planning while monitoring their comprehension and learning progress throughout.

During the performance or volitional phase, self-regulated learners complete tasks by devising and completing various suitable sub-task strategies, developing a favourable learning environment, seeking help from different sources if required, instructing themselves and managing their time. All of this occurs as the learner applies metacognitive monitoring and self-recording to achieve set goals.

Rajabi (2012, p. 374) found team or collaborative work to be a beneficial approach to developing the self-regulated learning skills illustrated in the performance phase. He argues that the likelihood of developing skills such as help-seeking, self-instruction, time management, different reasoning and task strategies seems to improve in classes where students have the chance to collaborate with their classmates. In a similar vein, Melzner et al. (2019, p. 318) aver that teachers should verbalise their expectations for

learners' success and create a cooperative learning environment where learners can practise what they are learning and consult with teachers and peers as needed throughout the learning process. A self-regulated learner, for instance, can record their successes and experiment with new strategies to acquire feedback for their self-monitoring process and refine their learning practices.

Modelling is one teaching strategy that teachers can employ during all three phases to help students build metacognitive monitoring and self-regulated learning skills in the classroom. Schunk, Pintrich and Meece (2016, p. 148) define modelling as the behavioural, cognitive and affective changes that result from seeing behaviour being modelled by other people such as teachers. Modelling provides students with visual and verbal examples of what they are expected to learn. Therefore, modelling is a teaching strategy through which students can learn new knowledge, skills and behaviours vicariously by observing what teachers do rather than through first-hand experience or trial-and-error learning attempts (Koutroubas & Galanakis 2022, p. 317). Observational learning accelerates the learning process because students can notice information, abilities and attitudes from others without having to imitate them or risk having unpleasant experiences. It also inspires students to set challenging yet achievable objectives for themselves.

By observing how models approach self-regulated learning, how they model tasks and performance and how they model their metacognition, learners can also acquire self-regulated learning strategies (Koutroubas & Galanakis 2022, p. 317). For instance, Beach et al. (2020, p. 3) suggest that during the performance phase, teachers make both their own and their students' thought processes explicit by demonstrating task strategies and asking learners' provocative questions instead of giving them answers. Teachers can furthermore use explicit metacognitive language and teaching and show students how their learning is connected across and within subjects, as well as teaching learners how to interpret feedback. When teachers use such teaching strategies, learners get the opportunity to see how teachers think and are encouraged to imitate the behaviour that fosters learning (Agbenyegah 2022, p. 52; Koutroubas & Galanakis 2022, p. 317).

The last stage in Zimmerman and Moylan's (2009) model is the self-reflection phase. In this stage, learners assess the procedures they followed to complete their tasks and determine whether their strategies were effective enough to achieve their objectives. To proceed towards the desired outcome and achieve their goals, they choose whether they need to revisit existing task strategies or try new ones. For instance, the learners might realise that they need to acquire help from peers or a teacher because

the learning task is too challenging to analyse. They may realise that they might have used ineffective preparation techniques and therefore adjust by seeking help and using different task strategies. Examples of effective task strategies are among others, underlining or highlighting important ideas in a text, making summaries of main and supporting ideas in a text, and using mnemonics to remember content (Joseph-Edwards 2019, p. 10). The students' self-reflection and recognition of their inadequately initiated task strategies will thus prompt them to revisit and improve their strategies in subsequent tasks (Zimmerman & Moylan 2009, p. 302).

During the self-reflection stage, teachers can help students improve their capacity for self-regulated learning by using formative and summative assessments. Formative assessment and self-assessment are critical in evaluating learners' knowledge, attitudes and learning abilities as they relate to developing aspects of self-regulated learning (Jossberger, Brand-Gruwel, Boshuizen, Van de Wiel, 2010, p. 23). Formative assessments, according to Jossberger et al. (2010, p. 23), can be designed to address aspects of self-regulated learning and provide students with the opportunity to reflect on their own learning progress and performance. Formative evaluations can also be utilised to establish an environment where students can get external feedback.

Regular feedback from teachers has been found to increase learners' efforts to advance and achieve better results, particularly in situations where learners lack information and where difficulties with learning persist (Jossberger et al. 2010, p. 27). Research has also suggested that in their feedback, teachers should outline clearly what areas of self-regulatory and self-effective learning the learner should focus on in order to excel academically (Ragvan 2022, p. 48). Teachers also need to be conscious of their disposition, conduct, teaching strategies and the expectations placed on them to help learners develop self-regulated learning skills (Jossberger et al. 2010, p. 36). Teachers should, furthermore, urge learners to take autonomy for their learning and assist them with help-seeking skills when they engage in homework tasks or are struggling with any area of learning (Ramdass & Zimmerman 2011, p. 197). The findings of Orange and Hodges' (2015, p. 10) study indicate that when completing homework, self-regulated learners typically employ effective study skills, have a positive attitude and are motivated to perform academically. Nunez et al. (2015, p. 376) aver that teachers can develop self-regulated learning skills, motivation, a passion for learning and metacognitive skills by showing learners how to prepare for class at home and to stay organised with their assignments and class work.

The United Kingdom-based Education Endowment Foundation (2018, p.14) outlined a seven-step methodology for explicitly teaching

metacognitive processes in their assessment of research on metacognition and self-regulation in schools. The steps include activating students' prior knowledge, explicit strategy instruction, modelling the learned approach, students' memorising the strategy, teachers providing guided practice, giving students the opportunity for independent practice and structured reflection. These strategies can be applied to students across different subject areas and age groups.

With the theories and literature discussed above, we gained insights into the influences of personal, behavioural and environmental determinants that enable or hinder participants' confidence and teaching skills to develop metacognitive and self-regulated learning skills in their students.

The research design and methodology followed in the study are explained in the section that follows.

## ■ Research design and methodology

The interpretivist paradigm served as the study's guiding paradigm to form an understanding of teachers' views of their confidence and teaching strategies to model self-regulated learning skills and metacognitive monitoring and develop similar skills in learners. The interpretivist paradigm guided the study in order to comprehend teachers' perceptions of their own confidence and teaching strategies for modelling metacognitive monitoring and self-regulated learning skills to help students acquire similar skills. Four characteristics are crucial to understanding the nature of qualitative research, according to Merriam (2009, p. 14). Firstly, qualitative researchers are focused on understanding the processes people go through with their experiences, how people interpret their own experiences and what meaning they attribute to those experiences. Secondly, the qualitative researcher serves as the main human instrument to collect and analyse data. Thirdly, data are analysed inductively, and fourthly, the findings are comprehensive and fully descriptive. The current study made use of a qualitative research approach because it incorporated these elements of qualitative research.

Employing a basic interpretive qualitative approach, the researchers sought a deeper understanding of the dynamics of teachers' confidence and pedagogical content knowledge in helping students develop self-regulated learning skills, such as metacognitive monitoring.

## ■ Sampling

The researchers used convenience sampling as well as purposeful sampling for this study. Purposively, 16 secondary school teachers were selected

based on their prior experience in teaching students in higher quintile schools. These secondary school teachers were purposefully chosen because they possessed knowledge about their confidence, perceptions, beliefs and experiences related to modelling metacognitive monitoring skills as a self-regulated learning skill.

Convenience sampling of schools was based on location and ease of access to the four secondary schools (three quintile-four schools and one quintile-five school) in the iLembe area of the KZN province for the first author of the study. The first author of this study has personal experience and insider knowledge of teaching in higher quintile schools in the iLembe district. She has a well-developed understanding of the research setting and could therefore easily contextualise and interpret the responses of participants in this study. The research was conducted at four secondary schools (three quintile-four schools and one quintile-five school) in the iLembe area of the KZN province (Ragvan 2022, p. 63). Public schools in South Africa are grouped into quintiles according to the socioeconomic standing of the surrounding community. Schools in the lower quintiles (one to three) are given more state funding than quintile-four and quintile-five schools (Spaull & Kotze 2015, p. 21). As students in higher quintile schools are generally thought to be more self-directed as a result of receiving more financial, emotional and cognitive support from their parents, we assumed that the teaching and learning environments in higher quintile schools are more conducive to the development of metacognitive and self-regulated learning (SRL) skills. We made the decision to investigate four higher quintile schools in KZN to learn from best practices. Participants had to meet certain requirements in order to be included: they had to be qualified secondary school teachers teaching any subject in Grades 8 through to Grade 11 at a higher quintile school in the iLembe district (Ragvan 2022, p. 61).

Examples of questions asked appear below.

- Could you please elaborate on why you believe you have, or do not have, enough confidence to help students build their metacognitive and SRL skills?
- What strategies do you employ to assist students in comprehending their work? Could you please give a few instances of the strategies you use?
- What do you do to teach students to check their own comprehension of the work?
- When you teach, do you model for students how you think by posing questions to yourself? For example, do you model how to thinking out loud, walking yourself through procedures and correcting yourself when you explain something are some ways to practice this. Give some instances, please.

## ■ Ethical considerations

The Education Sciences Research Ethics Committee (EduREC) granted ethical clearance for this study (ethical clearance number: NWU-01280-20-A2). The study proceeded following ethical approval from the various institutions involved, the KZN Department of Education and permission from the four secondary school principals in the KZN province's iLembe district, according to the guidelines of Ragvan (2022, p. 72). The researchers adhered to all ethical standards and guidelines for conducting research, including informed permission, confidentiality, anonymity and maintaining the participant's right to withdraw from the study (cf. Maree 2016). Before the study commenced, the participants provided written informed consent. Participants were free to leave at any time without any consequences, and none of them were coerced into taking part. Pseudonyms were employed to protect the identity of both schools and participants. Participants were assured of confidentiality because the researcher made sure that all information would be kept private, stored safely and available to the study team alone.

## ■ Data collection

Open-ended paper-based questionnaires and follow-up telephone interviews were used to collect data. A follow-up telephonic interview was required with two participants to clarify certain responses in the questionnaires. The questionnaire included questions that explored participants' confidence (or lack thereof) in developing self-regulated learning skills in learners. In the questionnaire, we also explored the teaching strategies participants use to help students understand academic material and how they went about helping them to set goals and make plans to complete learning tasks. The participants were asked to give examples and their rationale for using these strategies and to indicate their perceived effectiveness of the strategies they employed in teaching and how learners respond to them. The questionnaire explored how participants guide learners in assessing their comprehension, teach self-questioning techniques and prompt learners to consider their class preparation. It also aimed at gauging how participants emphasise the importance of learning beyond merely obtaining correct answers and promoting the development of metacognitive monitoring skills through learner self-assessment. Finally, participants were asked to describe whether and how they use think-aloud strategies, self-explanation and self-correction to demonstrate to students how they think while they are teaching subject matter.

## ■ Data analysis

To interpret the data and to answer the research questions of the study, the researchers used both content analysis and a thematic analysis. The steps of analysis described by Denscombe (2010) were applied by the researchers during the data analysis procedure. The first stage entailed the collection and preparation of data for transcription. Participants and schools were coded in the following manner: S stands for School, B specifies the specific school, P refers to the participant and the number following P is the number assigned to the participant. SBP3, for example, means the data come from School B and the participant was participant 3. The third stage involved the classifying and coding of data, grouping of the codes according to themes created and comparing the information gathered. The results were recorded and analysed in the fourth stage.

The study identified two themes: Confidence to develop metacognitive monitoring and self-regulated learning skills in learners and perceptions of how metacognitive monitoring as self-regulated learning skill is developed. Six sub-themes emerged from the two main themes. These are discussed in the following sections.

## ■ Findings and discussion

In the discussion of the findings below, three qualifiers accompany the exact quotations from the data to identify the specific participant and the school.

### ■ Theme 1: Confidence to develop metacognitive monitoring and self-regulated learning skills in learners

When asked if they believed they possessed the confidence, expertise and abilities required to support their students in acquiring metacognitive monitoring and other self-regulated learning skills, 11 participants confirmed with a 'yes' response. Some responses are given below:

'Yes, I do have the knowledge and skills to develop metacognition and self-regulated learning skills in our learners. The nature of class activities, assessments, and tests encourage and motivate learners toward self-regulated learning. Learners are encouraged to work through critical thinking questions and activities and do effective research to increase their knowledge and understanding.' (SAP1, Female, 26 August 2021).

'Yes, I have experience in teaching for 35 years and have continuous involvement in my personal professional development. I read avidly and keep up with the current trend in education worldwide.' (SBP2, Female, 26 August 2021)

'Yes, I do, my teaching specialisation Life Orientation focuses on developing these skills in my learners. For example, the things learners should do before they begin to study, what they should be doing whilst they study, and also what they should do after they have completed learning any specific content.' (SDP4, Female, 26 August 2021)

'Yes, it is important for an educator to have confidence in the classroom. When they are confident, the atmosphere of the classroom changes, and all works out well. I believe I have the confidence because I believe in my abilities, and I know my learners as well as their personal learning styles.' (SCP3, Female, 26 August 2021)

Eleven participants believed they had the confidence, knowledge and abilities to foster metacognitive monitoring and other self-regulated learning among their students, which is indicative of their teacher efficacy, academic and professional experiences (Powers et al. 2016, p. 1). Their responses are also supported by Peeters et al. (2014, p. 1963), who noted that as independent learners themselves, teachers should have the requisite competence to learn from teaching and to demonstrate self-regulated learning skills. For instance, participants indicated they looked for constructive feedback about their teaching, asked for guidance from mentors and read professional literature for new ideas in teaching (Ragvan 2022, p. 38).

In addition to the majority of positive answers, five participants said they lacked the confidence knowledge and teaching abilities necessary to cultivate and develop metacognitive monitoring and other self-regulated learning skills. The following were some of their responses:

'No, I need to be workshopped and provided materials on this aspect because our learners are too used to being "spoon-fed," as a result, I cannot suddenly change my teaching style and would need assistance to make that change. We teach to prepare learners for exams. There is no time to teach and encourage curiosity and exploration.' (SDP3, Female, 26 August 2021)

'An overload of paperwork placed on a teacher makes it difficult to carry out activities in an effective manner. A teacher can lose confidence when overburdened with paperwork, as they feel that they do not have much left of themselves to help learners.' (SAP2, Female, 26 August 2021)

'Contextual factors make it difficult to assist learners in an individual capacity. Many learners are second-language learners and need special attention, which is not always possible.' (SAP1, Female, 26 August 2021)

'Lack of formal training or workshop on self-regulated learning.' (SDP2, Male, 26 August 2021)

According to the evidence, five participants lack confidence in developing self-regulated learning skills among students. Their low confidence was associated with their workload, transmission teaching styles and a lack of professional development through continuous studies or workshops.

This theme revealed that both personal and environmental factors influence teachers' confidence in various ways. Personal factors that positively impact participants' confidence include continuous involvement in professional development courses, their professional teacher training, teacher efficacy (Geduld 2019, p. 63; Joseph-Edwards 2019, p. 6; Koutroubas & Galanakis 2022, p. 317; Powers et al. 2016, p. 1) and their understanding of learners and their learning styles, and learning through collaboration with peers (Powers et al. 2016, p. 13).

Conversely, some participants' confidence is negatively affected by personal variables such as a lack of knowledge and teaching skills to foster metacognitive monitoring and self-regulated learning skills, low self-efficacy beliefs regarding their emotional capacity to support struggling students (Joseph-Edwards 2019, p. 6; Koutroubas & Galanakis 2022, p. 317; Powers et al. 2016, p. 1). Behavioural determinants such as the use of teacher-centred teaching approaches focused on memorisation for good examination results negatively affect their confidence because they are aware of the detrimental effects of 'spoonfeeding' students.

Environmental factors such as the lack of professional development courses, continuous studies or workshops to assist participants (Beach et al. 2020, p. 12; Delfino & Persico 2018, p. 841), time constraints because of curriculum pressure, an overload of administrative work, departmental pressure for high pass rates (Dignath 2016, p. 84; Geduld 2019, p. 63) and students who struggle with English language instruction (Baloyi 2020, pp. 25–26) also hinder participants' confidence in developing metacognitive monitoring and other self-regulated learning skills.

## ■ **Theme 2: Perceptions of how metacognitive monitoring as SRL skill is developed**

The following sections discuss the participants' perceptions of their metacognitive monitoring development as a self-regulated learning skill in students and the six sub-themes relating to their teaching strategies.

### □ **Theme 2.1: Modelling of self-questioning through think-aloud strategies**

A few participants mentioned that they encouraged students to develop their own questions about the learning material before, during and after they begin a learning task because they feel that doing so helps students develop their metacognitive skills, which in turn helps them understand the subject better than before. They indicated the aim of self-questioning to be to teach learners to test their own prior knowledge about a topic beforehand, test their understanding of what they are learning during task completion,

and test their own understanding and performance after completing a task. These strategies are substantiated by research such as that of Beach et al. (2020, pp. 3–6) and Jossberger et al. (2010, p. 23).

The following responses best describe their teaching strategies:

‘I do activities that are related to the topic discussed. I teach them to create own questions and self-test to determine if they understand the work. I encourage learners to ask themselves questions and to be able to answer those questions without the help of their notebooks, before, during, and after any content had been taught.’ (SAP2, Female, 26 August 2021)

‘I ask my learners to generate their questions. They share their questions with their peers and thereafter respond to their peer’s questions as well as their own.’ (SDP4, Male, 26 August 2021)

Participants explained that they model metacognitive monitoring when they show their students how they think aloud and talk to themselves when they must understand new content and analyse tasks or instructions. By observing participants’ thinking aloud, students learn and emulate metacognitive monitoring skills, such as how to question their own understanding and task strategies, to explain content to themselves (self-instruction), and how to correct their mistakes (cf. Agbenyegah 2022, p. 52; Peel 2017, p. 72; Saliso & Ransom 2014, p. 56). Here are some examples of responses that reflect this:

‘When teaching a poetry lesson, for example, I usually ask myself questions out aloud to help me understand where the poet is coming from, his or her feelings, intentions, and tone. This is to show learners how to analyse the poem, how to break it down, and get a deeper understanding.’ (SAP1, Female, 26 August 2021)

‘During discussions, I place myself in scenarios to make it easier to explain and bring across the understanding. If I make a mistake during the teaching process, I immediately explain to the learners where I made a mistake and explain it correctly to bring clarity.’ (SAP2, Female, 26 August 2021)

‘It helps learners to see that I also question myself, think out aloud and correct myself so that they find the teacher is not all-knowing but there is always room for improvement. This encourages them to do the same and to build confidence in their abilities.’ (SCP4, Male, 26 August 2021)

‘Thinking out aloud during reading comprehension. Correcting myself verbally if I make an error while explaining. Rewriting sentences on the chalkboard with explanations to correct my own understanding and possible mistakes.’ (SDP3, English, Male, 26 August 2021)

These strategies collectively illustrate how participants believe they foster metacognitive monitoring and self-regulated learning skills in their students by integrating self-questioning and thinking aloud into their teaching practices. It can be concluded from the responses that participants’ personal and behavioural determinants, specifically their teaching experience and the teaching strategies they utilise, capacitate them to model self-questioning through think-aloud strategies.

## □ Theme 2.2: Before preparing for a class

Participants also mentioned that they taught students how to prepare for class at home to foster in them metacognitive skills such as becoming aware of their current state of understanding about the topic, what is still confusing and what task strategies they can apply to understand the topic better. This strategy is supported by Nunez et al. (2015, p. 376).

Responses indicate that personal and behavioural determinants influence participants' dispositions and the self-regulated learning skills they practice as teachers, such as planning and goal setting, as beneficial for the development of their learners' self-regulated learning skills (cf. Saliso & Ransom 2014, p. 56; Schunk et al. 2016, p. 148). One participant described how they developed abilities in accordance with their disposition and provided examples from which learners can also learn self-regulated learning techniques (cf. Saliso & Ransom 2014, p. 56):

'I show my learners my methods of planning. For example, the template I use to prepare myself for each of my lessons (my daily forecast file). I have also shown my learners a copy of my lesson plan. Things that I will do during my lesson, things I expect my learners to do in my lesson, and also what I want to achieve my objectives from that lesson.' (SDP4, Male, 26 August 2021)

Participants indicated that they advise students to bring all the materials they will need to class. Asking students to explain what and how they prepare for lessons will allow them to reflect on their preparation practices (Nunez et al. 2015, p. 376). As preparation, students typically do their homework and keep their notes current. These classroom conversations offer a forum where students can acquire helpful practices from their peers (Ragvan 2022, p. 93). The following responses from participants show how they got students to consider their prior preparation for class:

'I communicate to learners what is expected from them by explaining to them the activities that need to be completed as well as the notes that they should read to be prepared for the next lesson.' (SAP2, Female, 26 August 2021)

'Before I end the lesson, I give learners questions that are related to the next lessons. This is meant to prompt learners, to get their previous knowledge on a certain topic before we move on to the new knowledge.' (SAP3, Female, 26 August 2021)

'I provide key questions and give them sources for reading prior to commencing a new section.' (SCP2, Female, 26 August 2021)

'I encourage learners to do the reading/notes on the material before the lesson, then ask them to review the work again.' (SBP1, Female, 26 August 2021)

'They should arrive early, settle down and get ready for the business of the day. Go over what they have already learnt. Test their understanding of the content already covered. They must be organised, books in school, pens, and pencils, readily available. Carry all necessary items required for the lesson' (SBP4, Female, 26 August 2021)

The majority of participants (SAP2, Female, 26 August 2021); (SAP3, Female, 26 August 2021); (SBP4, Female, 26 August 2021); (SCP2, Female, 26 August 2021); and (SDP4, Female, 26 August 2021) use literature-supported development techniques for the metacognitive monitoring as a self-regulated learning skill (cf. Jossberger et al. 2010, p. 36; Peel 2017, p. 72). The pedagogical content strategies, a behavioural determinant, used by various participants include communication of teacher expectations, students' self-questioning, preparatory reading and reviewing of one's prior knowledge. These strategies emphasise the importance of understanding the learning material, providing key questions and encouraging learners to review their work before the lesson. Moreover, the strategies also emphasise the importance of punctuality, organisation and having necessary items readily available for the lesson. Participants also emphasise the importance of preparing students for the day ahead. Consequently, more insightful class discussions and learner engagement occur because of learners' preparation and familiarity with the material (Ragvan 2022, p. 94). It can be concluded that personal determinants, such as participants' individual motivation to teach, influence their planning and teaching strategies, which are behavioural determinants.

### □ **Theme 2.3: Homework as a mental exercise that promotes readiness to learn**

Participants also thought that students doing their assignments at home was a way to practise metacognitive monitoring. They added that homework gives students the chance to consider the work they have done in class and to solidify their new knowledge through homework assignments that are based on the day's class assignments (cf. Orange & Hodges 2015, p. 10; Ramdass & Zimmerman 2011, p. 197). Participants see homework as a form of mental preparation that encourages learners' preparedness to learn by having them review previously taught material and test their past knowledge. This is how one participant explained:

'Do activities that are related to the topic discussed. Create own questions and self-test to determine if they understand the work... I encourage learners to ask themselves questions and to be able to answer those questions without the help of their notebooks. I encourage learners to self-question before, during, and after any content being looked at.' (SAP2, Female, 26 August 2021).

'Peer marking of topic tests. Copies of exam memos to show them what is required to achieve full marks.' (SDP1, Male, 26 August 2021)

The homework questions respond to review questions from earlier papers, peer evaluation and discussion of the memos the following day. Questions on the homework assignment may also invite students to consider their own beliefs and concepts.

One participant mentioned giving learners exam papers from prior years to answer as homework activities. However, when unaccompanied by efforts to foster learners' metacognitive learning skills and their abilities to control their own learning, reviewing exam questions from prior years becomes teaching-to-test practice, which is discouraged by modern education research. On the other hand, understanding, memorisation and practice can be viewed as the beginning of a meaningful learning experience for learners if learners are active, constructive, engaged and know how to apply knowledge to new situations. One participant explained it like this:

'I give learners homework that are related to the work we were doing in class that day. I give learners previous papers to answer, then we discuss the memo. They exchange notebooks and mark for each other when it's a novel or drama, there are always questions that allow learners to reflect and think about their own opinions and ideas.' (SAP3, Female, 26 August 2021)

## □ Theme 2.4: Learning to learn versus getting the correct answer

Teachers should instil a strong emphasis on learning in their learners while helping them develop metacognitive monitoring skills. They should not only focus on getting the answer right, as learners might quickly forget the steps they used to arrive at the solution (cf. Jossberger et al. 2010, p. 24). Participants indicated that they discouraged rote memorisation by asking higher-order open-ended questions that facilitate critical thinking. Several participants believed that metacognitive skills are developed when learners learn from mistakes. Therefore, they encouraged their learners not to be afraid of making mistakes, as these are a part of the learning process. In addition, they remind their learners that learning is not only about getting high marks for correct answers but also about how the knowledge they gain will be applied in future (Ragvan 2022, p. 94). The participant's replies below show how they emphasised to their students the importance of knowing how to learn rather than just providing the correct answer:

'Learners should be encouraged to engage in elaboration and understanding of facts and ideas rather than rote repetition.... this can be achieved through purposeful questions which can help learners deepen their thinking and understanding rather than merely reaching the correct answer.' (SAP1, Female, 26 August 2021)

'In the learning process, mistakes are bound to happen. I motivate my learners by telling them that it is not about how many answers you get correct but ensuring that you learn from your mistakes in order to effectively apply knowledge in the long-term.' (SAP2, Female, 26 August 2021)

A few participants claimed that the South African educational system is fixated on having high pass rates and that is why many teachers do not highlight the significance of knowing how to learn as opposed to having the correct answer. One participant gave the following response:

‘We teach to prepare learners for exams. There is no time to teach and encourage curiosity and exploration’ (SDP3, Male, 26 August 2021).

This participant’s view is supported by Dignath (2016, p. 84), who found that because of work constraints, ‘some teachers spend very little time on promoting self-regulated strategy instructions’.

Teaching reading comprehension skills was another strategy mentioned by participants for fostering metacognitive monitoring and teaching learners that getting the right answer is less important than learning how to learn. This is how two participants clarified it:

‘I teach reading skills, critical reading skills. I encourage them to read for meaning and understanding. Reading for meaning allows one to engage in a critical understanding rather than right or wrong answers.’ (SBP2, Female, 26 August 2021)

‘I teach them to read their work several times until it makes sense to them. To write down words that they do not understand, and they find the definitions of those words. To read their work aloud to their peers or to themselves to understand what they have written helps.’ (SDP4, Female, 26 August 2021)

## □ Theme 2.5: Task strategies to develop cognitive and metacognitive skills

Participants in this study provided the following comments when asked which task strategies they employed to develop metacognitive skills and further aid their learners in understanding their work, as well as when and why they did so. Participants mentioned using the following strategies to strengthen learners’ cognition and develop metacognitive monitoring skills: Activating learners’ prior knowledge, using charts and flow diagrams to summarise and outline aspects of a topic, cooperative and peer learning (cf. Melzner et al. 2019, p. 318), considering diverse learning styles, using English language proficiencies and media and technology, mnemonics and imagery. Most of the strategies mentioned by the participants above are cognitive strategies that correspond with the task strategies (cf. Joseph-Edwards 2019, p. 10) that self-regulated learners use as illustrated in Zimmerman and Moylan’s (2009) model. One participant mentioned:

'I activate their prior knowledge to link their thoughts and ideas to the concept or topic being taught. I introduce vocabulary in context, so that learners can deduce the meaning of text through context ... used in comprehension passages, poems, novels, drama, and language. Prior knowledge always helps learners, taking them from a place of what they know to the unknown ... This linking assist[s] in learning and making meaningful connections.' (SAP1, Female, 26 August 2021) (cf. Peel 2017, p. 72)

'Charts and flow diagrams work for some learners. Others prefer to rewrite work. Learners with some language learning challenges are encouraged to use flash cards with parents and siblings. All learners are encouraged to use past papers ... My classroom is a diverse environment. Learners all do not learn at the same pace or same style. It takes time for me to understand what each of my learners' learning styles are or to remedy language and learning barriers, therefore different approaches are to be tried.' (SAP4, Female, 26 August 2021) (cf. Baloyi 2020, pp. 25-26)

Another participant (SBP1, Female, 26 August 2021) elucidated:

'I use co-operative learning, through verbally expressing themselves and responding to others their self-confidence is developed and communication skills and critical thinking skills are taught. Inquiry-based instruction is vital, by encouraging learners to ask questions and investigate ... This is conducted daily, such that I am able to respond to my learner's diverse needs. There is no one-size-fits-all method to help learners develop understanding but these strategies help to address individual needs.'

One participant (SCP1, Male, 26 August 2021) also valued peer work as a strategy to develop metacognitive learning skills: 'I encourage peer work ... I ask my learners to generate their questions and then share it with their peers and also respond to their peer's questions'.

Other participants mentioned cognitive learning strategies:

'The use of mnemonics improve memory and will become useful in remembering important dates, capital cities, etc. creating flow charts or mind maps... helps in understanding content. I get learners to highlight or underline important information ... I use these strategies in my everyday teaching ... this helps my learners remember and understand what they learn. Makes learning fun and encourages the learners when they perform well in a test or exam.' (SBP4, Female, 26 August 2021)

To develop metacognitive learning skills, two participants chose imagery (cf. Zimmerman & Moylan 2009, p. 302). One participant elaborated:

'I teach learners to visualise, when doing a poem learners must learn to form a picture of the imagery the poet describes ... connotations schemata theory, when learning new words, learners relate it to what they already know ... I use these strategies in my lessons. The incorporation of these strategies helps my learners understand the content in their way.' (SCP3, Female, 26 August 2021)

One participant (SDP4, Female, 26 August 2021) said:

'I space out learning over time and not on a day before exam, to cram their work. I provide a detailed explanations and descriptions of the content during lessons

with practical examples. I often combine written content with pictures during my lessons before learners attempt the class activities so that they can attain high marks for their assessments.'

## □ Theme 2.6: Peer and self-assessment for developing metacognitive skills

The following participant responses reveal how participants perceive themselves to develop metacognitive skills through self-assessment and peer assessment. Participants' self-assessment and peer-assessment practices are more focused on examination preparation, although they perceived it to be developing learners' knowledge of how they learn and thus their metacognitive skills. Participants believe that peer assessment gives students the chance to learn from the errors of their peers as well as the appropriate ways to do their work in the future (cf. Jossberger et al. 2010, p. 23). Participants indicated that with peer assessment, students can familiarise themselves with what is expected of them. These techniques are essential for helping learners reflect on their progress and comprehension as they must monitor their own metacognitive processes to improve their work (cf. Jossberger et al. 2010, p. 23). This is how participants explained how peer assessment and self-assessment promote the development of metacognitive skills:

'Learners correct their work from the correction/rubric given. Learners do peer marking of activities.' (SAP1, Female, 26 August 2021)

'Self-assessment is conducted daily, where learners mark their class activities.' (SBP3 Female, 26 August 2021)

'Peer assessments, I give learners an assignment. They give it to their peers to mark using their textbooks.' (SCP1, Male, 26 August 2021)

'Learners mark their activities and complete remedial work. Learners also set their tests, answer their questions, and give themselves scores after they have conducted their test.' (SDP4, Female, 26 August 2021)

## ■ Conclusion

With regard to the first research question, participants' responses indicate that even though some may have confidence to foster self-regulated learning and metacognitive skills because of positive personal and professional factors, many participants lack confidence because of a combination of personal, behavioural and environmental challenges. Some participants' confidence is negatively impacted by low self-efficacy beliefs, a lack of knowledge and teaching skills, and emotional inabilities to support struggling students in general, and students with English language barriers specifically. While ongoing participation in professional development, training, well-resourced higher quintile schools and

commitment to teaching positively impact most participants' confidence, the absence thereof negatively impacts others' confidence leading them to still utilise transmission teaching approaches because they erroneously believe such an approach ensures good examination pass rates. Participants' confidence is furthermore hindered by departmental pressure for high pass rates, extensive workload, administrative duties and curriculum expectations.

With regard to the second research question, it can be concluded that participants who engage in continuous professional development and possess strong self-efficacy are more likely to model metacognitive monitoring skills as a self-regulated learning skill. These participants employ a range of teaching strategies, supported by literature, to promote students' metacognitive monitoring and enhance their abilities to self-regulate. Although some participants indicated that they lack confidence in developing metacognitive and self-regulated learning skills, the examples they provided acknowledge the development of some of these skills. This could mean that there is a discrepancy between participants' conceptual understanding of metacognitive monitoring skills as a self-regulated learning skill. Therefore, without being explicitly recognised, the development of metacognitive and self-regulated learning skills is, to some extent, included in their teaching strategies.

The modelling and growth of metacognitive and self-regulated learning skills depend so much on teachers' motivation, self-confidence and optimism, and therefore, the significance of teachers in helping students develop these skills should be emphasised by HEI and teacher preparation programmes.

Through the provision of metacognitive and self-regulated learning courses, HEI and Teacher Training Institutions can emphasise the importance of teachers' roles in assisting students in developing these skills. Additionally, teachers who are currently employed should get courses on the development of metacognitive and self-regulated learning skills throughout their teacher training from HEI. Teachers who have been in the educational system for a while but have not pursued further education would become more conscious of this. Professional development courses in the form of workshops could help working teachers by providing fresh ideas for their teaching strategies.

Teachers should be able to attend educational programmes from the Department of Basic Education (DBE) about the development of these skills. Each subject and learning area should include strategies for promoting self-regulated learning during teaching to include self-regulated learning abilities into the curriculum. Subject advisers ought to monitor teachers'

efforts to develop these skills. More class visits by school principals and school management teams (SMT) are necessary to pinpoint areas where teachers may better prepare their learners for metacognitive and self-regulated behaviour. Weekly class visits by Heads of Departments (HoDs) and additional meetings among teachers in the same department are necessary to allow them to exchange ideas and develop strategies that will improve the development of these skills among students.



# Exploring metacognition and motivation in classroom environments for successful learning in accounting<sup>4</sup>

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## ■ Abstract

In this chapter, an explanatory mixed method design was used to investigate accounting classroom environments in the Further Education and Training (FET) Phase in South Africa. The focus is on the qualitative phase that involved semi-structured individual interviews with learners and teachers, as well as observations in the accounting classroom to gain a more in-depth understanding of the learning environment and how metacognition

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and motivation enhance successful learning in the accounting classroom. The primary aim of this research study focuses on how metacognition and motivation influence the classroom conditions for learners to experience successful learning in the accounting classroom. Based on this deliberation, the purpose of the study was firstly to explore what skills accounting learners need to develop to support metacognition in the classroom environments to enhance successful learning in accounting. Secondly, in order to develop these metacognitive skills in the classroom, the role the motivation of learners plays in successful learning in accounting was investigated. Empirical evidence is provided to support the importance of motivation where positive relationships and attitudes towards the subject of accounting are practised and which, in the end, will contribute to motivating learners to persist and succeed in accounting. The study also provides evidence that when accounting teachers focus on the development of metacognitive skills, more self-directed learning (SDL) could take place, which could lead to better pass rates and academic performance in the subject of accounting.

## ■ Introduction

El Yazidi (2023, p. 26) emphasises the importance of the development of critical thinking skills and that teachers play a vital role in fostering these critical thinking and metacognitive skills in students. How teachers support and motivate students significantly influences their responsiveness to learning opportunities. The integration of active learning by teachers and their ability to encourage critical thinking, particularly in accounting, are key factors in student success. Van Tonder, Kloppers and Grosser (2022) assert that the effective use of cognitive and metacognitive skills is essential for learning success:

[C]ognitive [e]ducation involve[s] the development of thinking skills to promote independent, critical, and self-reflective thinking that is important for self-directed learning (SDL) and daily life problem-solving. Teaching should therefore involve more than just the acquisition of factual knowledge. (p. 78)

Schleifer and Dull (2009, p. 342) add that successful learners self-regulate their learning, achieving their academic goals through metacognitive, motivational and behavioural strategies. Walton (2010, p. 38) links successful learning to motivation and academic achievement.

However, Qhosola (2016, p. 125) finds that active learning is not consistently promoted in accounting classrooms. Qhosola (2016, p. 152) suggests that teachers often fail to engage students in ways conducive to deeper learning. For more profound learning, interactive learning is necessary, requiring teachers to create opportunities for student involvement. Qhosola (2016, p. 219) observes an unfortunate tendency

among teachers to make instructional choices that limit student engagement, leading to a significant number of passive and demotivated learners.

Textbooks remain the primary instructional tool, and teacher-centred methods are prevalent, often presenting theoretical content that students struggle to connect meaningfully with their lives (Qhosola 2016, p. 155). Research in accounting education highlights strategies for active learning in classrooms and professional practice, such as case studies, group-based activities and techniques for communication and critical thinking. Based on existing research in higher education, Wolcott and Sargent (2021, p. 5) recommend that accounting educators apply a model of cognitive development to better understand students' thinking and to design and employ more effective and active learning activities. Accordingly, Wolcott and Sargent (2021, p. 18) propose that students need to identify and adopt educational practices to generate graduates who have the critical thinking skills required by the rapidly changing profession.

Nagda, Gurin and Lopez (2010, p. 91) stress the importance of designing accounting classroom activities that prepare students for engaged, democratic and ethical community participation. Darling-Hammond and Richardson (2009, p. 49) note the need for teachers to foster students' higher-order thinking and performance skills. Ramsden (1992) acknowledges the complexity of identifying the 'best way' to teach, suggesting that teaching principles should be connected to student experiences. For years now, Accountancy South Africa (ASA) (2014, p. 6) highlight the need to move beyond the perception that studying accounting is merely about memorising rules. They point out the need to address gaps in learning and the development of metacognitive skills, such as problem-solving, abstract reasoning, basic mathematical and language skills, and the application of academic knowledge in professional settings. Therefore, exploring classroom activities in accounting that stimulate student engagement and enhance analytical and conceptual thinking is vital for effective learning.

## ■ Problem statement

Research in accounting education has uncovered techniques that can be effectively applied to critical thinking strategies, with a particular emphasis on metacognitive skills (Schleifer & Dull 2009, p. 352). 'In order to foster this competence, methodologies used by universities and teachers should accomplish certain features oriented to learning' (Del Campo, Urquía-Grande & Pascual-Ezama 2023). According to Del Campo et al. (2023, p. 178), 'the main characteristic of the different approaches to developing critical thinking in education is that it should be learner-centred instead of teacher-centred'.

These kinds of strategies can create an environment in which learning can take place (Gorski 2009, p. 315). This is important as accounting classroom activities should be explicitly designed to prepare learners for an active, democratic and ethical community, consequently encouraging them to become active transformers of the world around them (Nagda et al. 2010, p. 166).

Wentzel and Brophy (2014, p. 297) add that expressing learning goals, demonstrating task-related thinking and problem-solving, encouraging metacognitive awareness and control of learning strategies, teaching for conceptual change and lastly promoting self-directed learning (SDL) are important strategies for motivating successful learning. Moreover, teachers often provide learners with feedback designed to motivate them rather than only to inform them about the accuracy of their answers. The primary purpose of this motivational feedback is to get learners to work on tasks and to maintain productive task engagement. It is therefore important to note that virtually everything the teacher does has a potential motivational impact on learners (Thoonen et al. 2011, p. 512).

Several research studies have shown that metacognition, which entails understanding the goals of the learning process, figuring out the best strategies for learning and assessing whether the learning goals are being met, can help learners be academically successful and improve their performance in accounting (Schleifer & Dull 2009, p. 352).

Recent investigation of Karlen et al. (2023, p. 4) on 'how different aspects of teachers' competences affect their metacognitive practices can help improve the understanding of the teacher-level aspects that support or hinder the implementation of metacognition in class'. This realisation could yield fresh research on the relationship between many components of teachers' competence, particularly those pertaining to their roles as agents and self-regulated learners and how these qualities connect to one another in the context of teachers' professional development.

There have been requests for decades from many sectors within the accounting education fraternity, as well as universities, to address the shortcomings in learning, which were identified as difficulty with problem-solving, poor abstract reasoning skills, lack of basic skills (such as mathematical and language skills) and an inability to transfer academic knowledge to the workplace (ASA 2014, p. 6). Therefore, it is necessary to look into learning activities that can be incorporated in the classroom that can enhance learners' engagement with their subject material and result in improved analytical and conceptual thinking skills for successful learning in accounting.

Success in accounting can be seen as the achievement of improved performance in accounting (Coyle 2013, p. 248). Teachers, creating a

positive learning environment in the accounting classroom, might be able to provide more help to learners with their academic achievement. Academic success in accounting will be evident when the learners show the acquisition of specific knowledge and skills demonstrated through the completion of the accounting curriculum (York, Gibson & Rankin 2015, p. 16). Metacognition can help accounting learners to be academically successful and has the potential as a learning skill that can serve to improve accounting education.

According to Ngwenya (2014, p. 178), teachers think accounting is a subject that needs a specific type of practice and instruction. In accounting, learners are frequently faced with challenging problems which they have to solve together in order to develop higher-order reasoning and problem-solving skills. Frequent exposure to accounting scenarios and problems is important for learners to develop competence in different metacognitive skills. A lot of evidence exists which indicates that metacognition can help learners be academically successful, and if learners master these skills, it can improve accounting education (Schleifer & Dull 2009, p. 352).

'It has become increasingly important that university education develops [metacognitive] skills of students' (Goosen & Steenkamp 2023), and:

As some subjects in the accounting curriculum require a more structured problem-solving approach, while others require lateral and unstructured thinking, students need to be aware of their dominant learning styles (as this will determine their instinctive information gathering, processing and problem-solving approach in learning and assessments). Students should be able to [activate adaptive strategies] in [developing metacognitive skills]. (p. 10)

Within the context of this study, accounting teachers should encourage their learners to develop these skills specifically within cognitive activities like writing, comprehension, studying and problem-solving, because these are needed for academic success. Therefore, the research reported in this chapter aims to answer the research question and sub-questions listed below.

The primary research question is:

- How do metacognition and motivation influence the conditions for successful learning in the accounting classroom?

The sub-questions are:

- What specific skills do accounting learners need to develop to enhance metacognition in the classroom, contributing to successful learning in accounting?
- To what extent does learner motivation play a role in fostering the development of metacognitive skills and facilitating successful learning in the accounting classroom?

- Can a focus on the development of metacognitive skills in the accounting classroom lead to increased SDL, improved pass rates and enhanced academic performance in accounting?

## ■ Theoretical framework

This chapter identifies constructivism as the key influence in designing instructional strategies to enhance metacognitive skills essential for effective learning in accounting classrooms.

As an educational approach, constructivism posits that knowledge is constructed through personal experiences and interactions with the external world (Agarkar 2019, p. 854).

Constructivist teaching hinges on the idea that individuals comprehend information better and meaningful learning occurs when learners actively construct knowledge and meaning rather than passively receive information (Zajda 2021, p. 38). This approach positions learners as active creators of meaning and knowledge, promoting critical thinking and fostering motivated, independent learners crucial for learning accounting (Terblanche & De Clercq 2021, p. 336).

The study, focusing on how metacognition and motivation affect successful learning in accounting, is grounded in a fundamental constructivist premise: learning is contextually situated. This concept underscores the significance of context in teaching and learning. Alshurafat et al. (2021, p. 194) indicate that classroom environments should cultivate positive attitudes and motivation to facilitate successful learning in accounting, enabling learners to apply and practise metacognitive skills vital for success in this field.

Within this study's framework, the researcher concentrated on aspects that linked constructivist principles with learning activities in the accounting classroom, examining the influence of motivation on successful learning. Furthermore, the constructivist approach uses interactive teaching methods and strategies. These methods and strategies effectively create classroom conditions conducive to successful learning (Alshurafat et al. 2021, p. 194).

## ■ Conceptual framework

### ■ Metacognition in accounting

Metacognition is thinking about thinking and is a very useful mechanism to enhance student learning, both for immediate outcomes and for helping

learners understand their own learning processes (Owen 2017, p. 129). According to Flavell (1979, pp. 906–911), metacognition is ‘knowledge and cognition about cognitive phenomena’. Metacognition stems from an individual’s understanding and awareness of own cognition and regulation (Flavell 1979, p. 906). Reflective thinking, as a component of metacognition, is the ability to reflect critically on learning processes in order to perform successfully.

According to Schleifer and Dull (2009, p. 352), a variety of cognitive and metacognitive skills and methods must be used for learning to be successful. Accordingly, successful learners self-regulate their learning on a metacognitive, motivational and behavioural level to succeed and reach their goals. Metacognition skills are the ability to think about one’s own thinking and learning processes and monitor and regulate them effectively. Metacognitive awareness arises when cognition is managed and controlled (e.g. knowledge of feelings and learning strategies) (Legg & Locker 2009, p. 347). Metacognitive monitoring is the informal mental tracking of one’s performance outcomes, such as learning processes and the success of those processes in producing learning (Zimmerman & Moylan 2009, p. 303). Monitoring, according to Lai (2011, p. 40), is related to planning and assessing and involves paying attention to, and being aware of comprehension and task performance (Schraw & Moshman 1995, pp. 351–371). Monitoring engages memory and practice during reflection and synchronises the cognitive processes, claim Akyol and Garrison (2011, p. 183).

Metacognition skills are important for accounting learners at the school level, as they can help them improve their understanding of accounting concepts, principles and procedures and apply them to various problems and situations (Schleifer & Dull 2009, p. 352).

Some examples of metacognition skills that accounting learners need are outlined below.

- **Planning:** Accounting learners should be able to set clear and realistic goals for their learning, identify the resources and strategies they need to achieve them and allocate their time and effort accordingly. For example, before starting a new accounting topic, they should ask themselves what they want to learn, what they already know and how they can use their prior knowledge to help them learn. They should also plan how they will study the topic by reading the textbook, taking notes, doing exercises or seeking feedback from others.
- **Monitoring:** Accounting learners should be able to check their progress and comprehension during the learning process and adjust their strategies if needed. For example, while studying an accounting topic,

they should ask themselves questions such as: Do I understand the main ideas? Can I explain them in my own words? Can I apply them to different examples? Do I need more practice or clarification? They should also use various methods to monitor their learning, such as reviewing their notes, summarising the key points, testing themselves or comparing their answers with others.

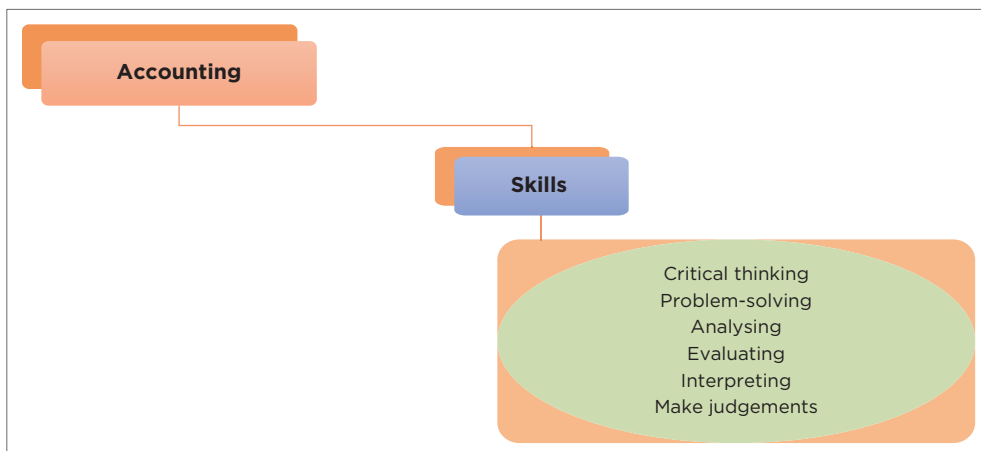
- Evaluation: Accounting learners should be able to reflect on their learning outcomes and experiences and identify their strengths and weaknesses. For example, after completing an accounting topic or assignment, they should ask themselves questions such as: Did I achieve my goals? What did I learn? What did I do well? What did I struggle with? How can I improve my performance next time? They should also seek feedback from others, such as teachers, peers or tutors, and use it to improve their learning.

‘Based on the theories of metacognition and self-regulated learning, a reflective self-assessment workshop on learning styles was developed’ by Karlen et al. (2023, p. 16) and implemented in a postgraduate accounting programme to show the importance of all these skills for the subject accounting (Goosen & Seenkamp 2023).

According to Exintaris, Karunaratne and Yuriev (2023, p. 2), it takes a variety of talents, including process expertise, critical thinking abilities, metacognitive awareness and deep conceptual reasoning to solve problems successfully. Teaching strategies that assist students in acquiring problem-solving abilities include instructional scaffolding, metacognitive strategies and other critical thinking skills needed for successful learning.

## ■ Critical thinking in accounting

The American Institute of Certified Public Accountants (AICPA) emphasises the importance of strategic critical thinking skills for accountants, including effective communication, ethical decision-making and logical analysis (AICPA 1999). These skills are crucial for accountants to be effective in their roles, especially in a competitive business environment (Freeley & Steinberg 2000, p. 322). Thus, incorporating critical thinking into accounting education is imperative because technical skills alone are insufficient for success in accounting. Accountants also require critical thinking, communication, teamwork, ethical awareness and technological competence (Hall, Ramsay & Raven 2004, p. 491). This necessitates an educational approach that covers technical aspects and broader skills, guiding teachers to integrate them into the curriculum. According to the researcher, the following skills illustrated in Figure 6.1 are essential to develop in the modern classroom.



Source: Petzer 2019, p. 227.

**FIGURE 6.1:** Skills needed for accounting learners.

Accounting has evolved over the ages, and in the present, it has been constantly developing, and in modern conditions, it is in the process of transformation as a result of several issues pertaining to the advancement of automation, artificial intelligence (AI) and information technology. It is now evident that accounting began as a practical activity in antiquity and developed into a science, a profession and a set of regulations pertaining to professional expertise and qualifications. As a science and a profession, accounting is always changing to meet the demands of business, the economy and society (Nikolova 2023, p. 143).

Modern accounting education should transition from focusing on routine tasks to promoting analytical and conceptual learning, which effectively develops the requisite competencies in accounting. Prudence in decision-making has been increasingly acknowledged by the accounting and auditing sectors as a key component of professionalism because people who make important decisions and judgements include managers, auditors, financial analysts, accountants and standard-setters. In real life, managers and accountants select accounting procedures and make decisions based on what best serves their goals, particularly when generating accounting data (Kamau & Ilamoya 2023, p. 20).

Engaging with real-life accounting problems is vital for developing advanced reasoning and problem-solving skills (Farrell & Farrell 2008). Pasewark (2021, p. 138) suggested that the Accounting Education Change Commission (AECC) focus on the problem-solving process that advocates for teaching methods that involve active participation and cooperative learning,

emphasising the importance of communication skills and collaborative problem-solving. Critical thinking in accounting encompasses a wide range of cognitive skills, including interpretation, analysis, evaluation and self-regulation (Camp & Schnader 2010, p. 665; Facione & Facione 2013, p. 98). These skills are essential for accountants to analyse situations effectively, make decisions and apply knowledge across various contexts.

Effective teaching strategies in accounting that foster critical thinking and problem-solving focus on active learning techniques such as problem-solving exercises, small group activities and simulations (Carter & Hogan 2013, p. 10). These methods improve analytical skills and increase student motivation and engagement with the subject matter.

In summary, a need for a comprehensive approach to accounting education that goes beyond technical knowledge, emphasising critical thinking, practical skills and active learning methods to prepare accountants for the challenges of the professional world and motivate students to succeed.

## ■ Motivation in accounting

A key aspect in motivating learners to be successful in accounting is that it is important for accounting teachers to be perceived by their learners as effective. In particular, it was found that learners who performed better are those who did more in terms of reading ahead, doing homework and participating in class because their teachers were experienced as effective in teaching accounting (Darwin 2011, p. 9).

## ■ Teacher's role in motivating accounting students

Teachers play a pivotal role in motivating students, especially in subjects like accounting. Darwin (2011, p. 9) emphasises the importance of accounting teachers being viewed favourably by their learners, as this motivates students to excel in the subject. This involves encouraging learners to actively engage with the subject matter, going beyond the given information and integrating it into their own thinking and understanding, as highlighted by Carter and Hogan (2013, p. 8). The Association for Education in Journalism and Mass Communication (AECC) advocates for innovative teaching techniques to boost motivation, moving away from traditional lectures to more active, team-learning formats (Carter & Hogan 2013, p. 8). Albrecht and Sack (2000, p. 52) also note the significant positive impact of multimedia materials on learners' motivation to study accounting, underscoring teachers' role in effectively integrating such resources.

## ■ Classroom environment and motivation

The classroom environment is integral to fostering student motivation. According to Darwin (2011, p. 13), creating conditions where learners are continually motivated is a critical goal for teachers. This includes making lessons meaningful and being responsive to the challenges learners face. Wentzel and Brophy (2014, p. 322) suggest that motivation is enhanced when the curriculum is aligned with learners' interests and abilities and when teachers emphasise practical activities. The inclusion of technology in the classroom, such as e-learning and other technology-based techniques, also plays a significant role in enhancing vocational skills and promoting SDL, which is vital for students' future professions in accounting (Pan et al. 2020, p. 564).

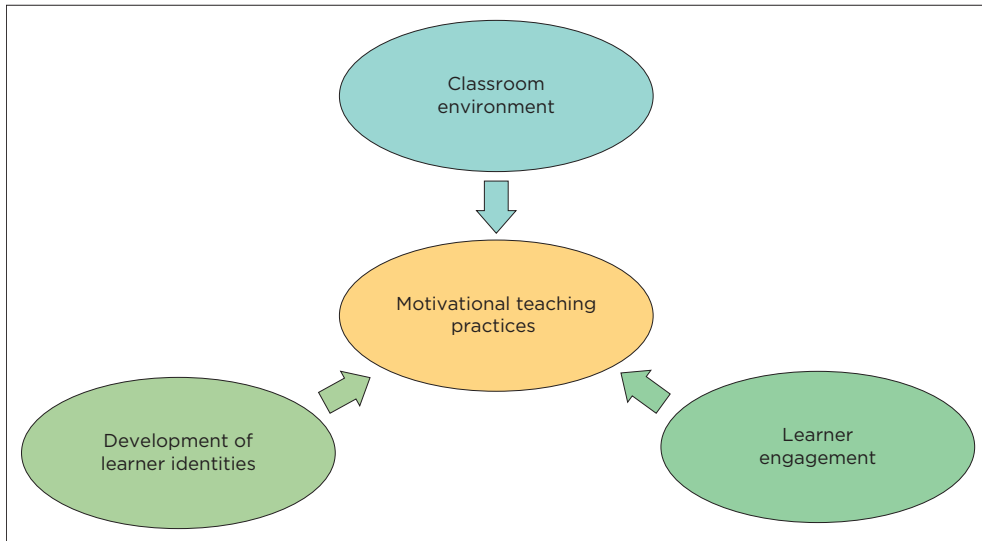
## ■ Learner engagement and motivation

Learner engagement is closely tied to motivation. Lee (2023, p. 15) found that motivation is boosted when students have opportunities to make choices during their classes. This sense of autonomy leads to more positive learning outcomes, especially when learners perceive that their teachers care about their choices (Osterman 2023, p. 978). The perception of teacher care enhances motivation and influences learners' beliefs about their control over their own learning, contributing significantly to their engagement and academic success.

## ■ Developing positive learner identities

The development of positive learner identities is crucial for academic motivation and performance. Lin-Siegler, Dweck and Cohen (2016, p. 295) show that learners' beliefs about themselves and their ability to succeed in intellectual activities significantly affect their motivation and school performance. Therefore, designing instructional activities that positively change learners' attitudes and beliefs is vital. Skinner, Zimmer-Gembeck and Connell (1998) further explain that learners who perceive their teachers as caring are likely to develop positive beliefs about their control over learning. Conversely, if teachers are perceived as uncaring, learners may develop external control beliefs, leading to lower academic achievement and negative attitudes towards school.

In Figure 6.2, Guilloteaux and Dörnyei's (2008, p. 58) constructed a model on three aspects of motivational teaching practice to guide the understanding of the processes essential for learner motivation. This includes classroom environment, learner engagement and development of learner identities.



Source: Adapted from Guilloteaux and Dörnyei's 2008, p. 58.

**FIGURE 6.2:** Motivational teaching practices.

- The importance of the classroom environment – the classroom is stimulating and purposeful, an environment that is supportive and safe and characterised by cooperative learning.
- Learner engagement that focuses on attitudes and successes, ownership and independence, relevance and involvement.
- The development of learner identities that focus on a learner's positive image of himself or herself.

Dörnyei (2007, p. 287) identified that sustained learning cannot take place unless the educational context provides sufficient inspiration and enjoyment to build up continuing motivation in the learners. Boring but systematic teaching can produce, for example, good test results but seldom does it inspire life-long commitment to the subject matter. These sections highlight the multifaceted nature of motivation in education, particularly in the context of accounting studies, where teacher roles, classroom environments, learner engagement and the development of positive learner identities all play a critical role. Linking motivation and achievement seems much more complex and dynamic than can be explained through attitudes to work and ensuing test results. Consequently, understanding the relationship between motivation and academic achievement is critical within education (Cheng, Li & Su 2011, pp. 1303-1314). This requires the identification of factors that nurture motivation with which teachers may positively influence learners' academic achievement (Goodman et al. 2011, pp. 373-385).

## ■ Research methodology

### ■ Research paradigm and design

This study supports research, which is pragmatic, focused on exploring and understanding the research problem in social science research and then uses mixed approaches to obtain knowledge about the problem (Creswell 2009). Pragmatism can be applied to mixed methods research where the researcher draws conclusions from both quantitative and qualitative methods when they engage in their research (Creswell 2009).

The pragmatic paradigm seeks holistic and complete information regarding a research problem by making use of multiple methods of data collection, and the emphasis is on the research problem to obtain a complete picture (Creswell 2009; Maree & Van der Westhuizen 2007; Thomas 2009).

Overall, the research project from which this study was drawn made use of a sequential explanatory mixed method approach. The explanatory design is classified as one of the mixed methods designs where a researcher starts by conducting a quantitative phase and follows up on specific results with a qualitative phase. In this chapter, only the qualitative phase of this project is reported on, as the focus is to explain the primary results of the interviews and observation in more depth. The researcher will report only the results of the qualitative data analysis by discussing the transcriptions of the interviews with teachers and learners as well as the field notes taken during the classroom observations.

### ■ Population and sampling

In this study, 11 secondary schools in the Gauteng province in the Vaal Triangle area participated, as did all of the accounting teachers and students in Grades 10, 11 and 12 in these schools. The Gauteng Department of Education oversees each and every one of the selected institutions. Focusing specifically on accounting learners in Grades 10, 11 and 12 is necessary because these students choose the subject in Grade 10 with the intention of pursuing a career in accounting. The researcher randomly chose three accounting learners from each grade (10, 11 and 12) from the three schools in April 2018 to obtain the views of learners experiencing different accounting content and representing different grades. In addition, 13 learners who indicated that they wanted to take part in the qualitative phase voluntarily were also included. The sample of teachers was small, and therefore, all 12 of them were requested to participate in the qualitative phase. However, only six teachers indicated their willingness. Saturation, or the point at which no additional data or themes are observed in the data

and the researcher becomes confident that the category is saturated (Starks & Brown Trinidad 2007), occurred within the interviews with 13 learners and six teachers. The three schools in the Vaal Triangle that were selected for the observations reflected various socio-economic contexts where access to educational resources ranged from more readily available to scarce.

Ethical issues were considered, such as providing reciprocity to participants for their willingness to provide data, handling sensitive information and disclosing the purposes of the research (Creswell & Plano Clark 2011). The researcher's responsibility and ethical code of conduct towards the participants were very important in this study, not only in terms of permission from participants to participate in the study but also in terms of the kind of behaviour I demonstrated towards them (Hatch 2002).

Participants were informed that their participation was voluntary and that they would have the option to withdraw if they would choose to do so. They all signed a consent form as proof that they understood the procedure and expectations and as confirmation of their voluntary participation in the research study. No participant was, therefore, treated unfairly or included in the study under false pretences. The names of the participants were not exposed in the study when the results were reported in the thesis. They were also assured that all information would not be made available to anyone except me and my promoters. I assured the participants that the interviews recorded will not reveal their names. Each participant was allocated a number in the interview coding and analysis.

An ethical application was submitted to the Faculty of Human Sciences Research Committee of the North-West University in February 2017. The application was approved, allowing the researcher to conduct the research.

## ■ Research findings and discussions

The study used a sequential mixed method design, but in this chapter only the results of the qualitative data are analysed and discussed to express the views of the learners and teachers from the interviews and the observations.

Observations were done in three accounting classrooms at the selected schools where the researcher took observational notes of the learning conditions in the accounting classroom.

In the qualitative analysis of the data, direct quotes will be used to support themes, categories and sub-categories. For the learners, it will be

labelled as follows, for example: L1DGR10. 'L' refers to learner no. 1 with 'D' indicative of a particular school followed by the grade the learner was in, that is, Grade 10, at the time of the study.

The themes that were identified (Table 6.1) during the quantitative phase were used as a basis for formulating the questions asked during the semi-structured interviews with the purpose of explaining the results of the quantitative data.

**TABLE 6.1:** Outline of themes, categories and sub-categories.

Critical thinking	Categories	Sub-category
	Motivation	Questioning
	Learning actions	Practice

Source: Author's own work.

## ■ Theme 1: Critical thinking

Some of the learner participants seem not to know what the concept 'critical thinking' means, which is reflected in these comments: 'I'm not sure, I'm thinking of three different ones that it could be' (L5EGR10); 'I do not understand critical thinking' (L8TGR11); 'you have to think out of the box' (L10DGR12); and 'I think it will be like you have to think like complex and some of the topics leads to it' (L4EGR10).

Some of the learner participants asserted that they believe that critical thinking skills were incorporated in accounting:

'To me it is being able to break down the whole problem into smaller pieces and actually analyse everything for every exercise or like problem-solving for instance and give your opinion on this.' (L11TGR12)

'Because some questions, let's say it will be in a balance sheet, but they'll ask things from another line of work that you did' (L12EGR12); 'like with the income statement, you have to really dig deeper to see is this amount included or excluded and I think sometimes it is necessary if it's a trickier question' (L7EGR11); and '*Ek sal altyd krities dink en vra hoekom doen ek dit of waar kom dit vandaan, ek wil presies weet hoekom*' (I will always think critically and ask why or where does it come from, I want to know exactly why it happen) (L1DGR10).

A learner participant indicated that the teacher, '*gee ook altyd maar die moeilikste voorbeelde wat jy moet oefen om dit dan self te ontwikkel*' (always gives the most difficult examples what you need to practice to develop it yourselves) (L10DGR12), where another learner stated that the teacher 'will allow us to answer on our own' (L2EGR10) and another affirmed that the teacher 'reason it and link it with other things' (L6TGR11).

A few teacher participants expressed: 'critical thinking is a concept that brings the learner into much deeper level of thinking, e.g. when they need to solve problems' (T3EGR11); 'that is thinking about thinking' and 'giving them problems to solve, will teach them critical thinking' (T5DGR10).

Some concerns about this were also highlighted. One teacher participant declared that 'we do not teach this enough' (T4VGR12). Another teacher participant raised a concern about the time that is limited to finish all the curriculum content and there is 'no time to teach these skills' (T3EGR11), whereas another teacher expressed that 'teaching to the test' (T4VGR12) is the only way learners will pass the subject. One teacher indicated that these skills must be 'stimulated in class' (T2PGR10) and added that you 'need time to do this'.

## □ Category 1: Motivation

Many of the learners who participated in this study indicated that 'motivation is very important for Accounting' as they declared that 'because the subject is difficult and the work is a lot' (L3TGR10; L5EGR10; L8TGR11; L12EGR12; L9DGR12; L4EGR10; L7EGR11; L2EGR10; L2EGR10). Two learner participants mentioned with regard to homework that 'motivation is important for doing homework, you need to be motivated enough to do it' (L5EGR10; L6TGR11).

A few learner participants felt, 'it's good because you think also about your future, I don't want to do bad and that motivates you to do better and just improve' (L8TGR11; L12EGR12). One learner participant commented that she is 'excited and motivated now to study Accounting for the exam, because it's easy to learn' (L1DGR10). Some learner participants reported that 'to be successful, somebody must motivate you to do well' (L8TGR11); and 'I think you need somebody to motivate you, encourage you to say you can actually do this' (L4EGR10). Another learner participant stated that 'a lot of motivation comes from our teacher' and 'she motivates us all the time, because she wants you to do your best' (L3TGR10).

One learner participant felt that 'if you do not believe or if nobody says to you that you can do it, then you will not do it' (L9DGR12). Another learner participant added: 'I think for instance with me when I struggled with asset disposal, it's important that the teacher should motivate you to try harder' (L7EGR11). A few learner participants focused on the negative aspects they experienced with regard to motivation. One learner participant felt that 'I wouldn't have dropped out of Accounting if I was motivated' (L13DGR11). Another learner participant stated that 'you definitely need to be motivated, otherwise I would have dropped out of

the subject, because it's not the easiest subject and becomes more difficult as you go on' (L10DGR12).

At the same time, one learner participant mentioned that:

'[M]otivation is very important, especially in Grade 10 there are many students who drop out, because they feel if they get bad marks, they don't know why and there's no-one there to motivate you, you just feel like, 'I don't need this.' (L11TGR12)

One of the learner participants even said that 'I am any way going to be yelled at if I do not get it right' (L13DGR11).

From the teacher participants' perspectives, one teacher reported that 'motivation is important to keep them positive' (T3EGR11), while another stated: 'motivation is very important, and if you take a learner for Accounting that is not motivated, then you will have a learner that will be frustrated and will perform poorly in the subject' (T1DGR12). One teacher participant expressed, 'learners will not get distinctions if they are demotivated' (T2PGR10).

## □ **Category 2: Learning actions**

### □ **Sub-category 1: Questioning**

Questioning appeared to be seen as a learning action taken by most of the learners to understand the content of accounting better. During the interviews, they were asked to comment on the way questioning is done in the class and if they feel comfortable asking questions in the accounting classroom. Some of the learner participants reacted positively: 'I don't have to be scared of asking questions, if I really believe I don't know, then I will put up my hand and ask' (L7EGR11); 'of course you feel comfortable asking questions, if you don't understand, no-one's afraid to ask' (L3TGR10; L4EGR10); 'we can always ask her' (L8TGR11; L6TGR11); '*ons mag vra en ek's maar die een wat die meeste vrae vra*' (we are allowed to ask questions and I am the one asking the most questions) (L2EGR10); and 'we can ask questions when we want to and she answers us' (L12EGR12).

A few learner participants seem to have some concerns. One stated, 'I will raise my hand and ask, as long as it's not a stupid question' (L5EGR10), because he felt, 'that's not a very smart thing to do'. Another learner participant reported, '*party kinders is dalk bietjie skrikkerig met die vrae vra*' (some learners might be a bit scared to ask questions) (L9DGR12), and another expressed that 'bigger class discourages asking questions' and felt 'if some things are really difficult, but it's a small principle that I missed, I wouldn't ask, it's embarrassing' (L11TGR12). One learner stated, '*Ek vra nie, want my onderwyser beweeg so vinnig deur 'n werkkaart en as jy 'n gedeelte*

*gemis het en jy weet nie presies hoe hy by die antwoord uitgekom het nie, gaan hy net aan*' (I do not ask because the teacher rushes through the worksheet and if you missed a part and you don't know how did he get to the answer, he just proceeds) (L1DGR10).

Another learner commented that *'Ek sal nooit ooit weer iets vra nie, want juffrou se oë rol*' (I will never ask the teacher something because her eyes roll) (L13DGR11), whereas another learner felt the same, *'sy't 'n vraag gevra en toe steek ek my hand op, toe antwoord ek en toe was die antwoord nou verkeerd, maar toe rol sy haar oë, ek het van daai dag af nooit weer gemaklik gevoel nie*' (she asked a question and I put up my hand, then I answered and it was wrong, but she rolled her eyes and I never felt comfortable again) (L10DGR12). During my observations, I noted that in one classroom, learners asked the teacher many questions when they experienced problems. This classroom environment was very relaxed and positive, and I could observe a good relationship between learners and teachers. However, in another classroom, where the teacher seemed a bit annoyed, some learners were very quiet during the lesson and learners did not ask any questions. I also experienced this classroom environment as a bit tense, as learners were uncomfortable to ask questions.

### □ **Sub-category 2: Practice**

Most of the learner participants reported that working through exercises in class, as well as practising these exercises at home, is part of the learning actions they take. Some learner participants stated, *'Ek sou sê deur baie oefening, dis hoe 'n mens dit reg gekry het en as jy dit verkeerd het, dan doen jy nie dieselfde oefening nie maar 'n ander oefening*' (I would say through a lot of practice, that is how you get it right and if you have done it wrongly, then you try another exercise) (L13DGR11); 'the teacher practices with us and give activities and pushes us a lot to practice' (L3TGR10); and 'we get a lot of homework sometimes' (L5EGR10). Most of the learner participants also affirmed that doing exercises regularly is the way they prepare for tests and exams in accounting and they elaborated on how they make use of activities and exercises to learn. One learner reported that she *'het baie oefeninge uitgewerk, herhaal die heelyd en het net vraestelle uitwerk*' (worked through a lot of exercises, repeat the whole time and worked through exam papers) (L13DGR11; L10DGR12). Others stated they *'begin gewoonlik deur om teorie deur te lees en dan vat ek vraestelle*' (start to read through the theory and then I take the exam papers) (L9DGR12; L1DGR10); 'I'll basically just go through exercises done in class' (L8TGR11); and 'I'll do the exercises we've previously done again and then check if they're correct afterwards' (L4EGR10). One learner reported *'ek vat maar net die vorige aktiwiteite wat ons gedoen het, dan*

*doen ek net al daardie transaksies weer* (I just take the previous activities we have done then I just do those transactions again) (L1DGR10). One learner expressed, 'my way of learning is I learn better when I hear things' (L11TGR12) and another said 'I like to do stuff on rough, then I'll make it physical that I can see how it works and I use colour so it makes it easier' (L6TGR11).

A few learner participants stated 'I would redo the exercises that we had before by trial and error' (L7EGR11); and 'I think what helps, my favourite part of dealing with transactions is the quick ones, because normally, when you take too long on one, you start to panic' (L11TGR12),

However, a few learner participants asserted that they do not practise the examples or exercises again, they just 'I just look at it' (L12EGR12); '*ek kyk maar net oor dit*' (I just look over it) (L2EGR10); and 'I will look at it and refer back' (L6TGR11). One learner participant stated that 'I do not have time to do homework' (L13DGR11).

## ■ Interpretation of findings

For learners studying accounting in schools, metacognition skills are crucial because they can enhance their comprehension of accounting concepts, procedures and principles and enable them to apply them to a variety of issues and circumstances (Schleifer & Dull 2009). Accounting learners need to develop a wide range of cognitive skills, including interpretation, analysis, evaluation and self-regulation (Camp & Schnader 2010; Facione & Facione 2013). These skills are essential for accountants to analyse situations effectively, make decisions and apply knowledge across various contexts.

When interpreting the qualitative results in this chapter, it can be summarised that motivation in accounting will support the development of metacognitive skills. However, for motivation to really make an impact, it is essential for the teacher to create a positive, safe learning environment where the act of encouragement to learn and progress is central (see results category 1). It was mentioned during the interviews that the learners experience a comfortable positive learning environment, especially when the teacher supports them and they do not have to be scared of asking questions when they experience problems.

It seems that most of the learners experience motivation in the accounting classroom. This is evident in that most of the learners believe that the activities chosen by the teacher motivate them to complete the activities, and they indicated that the classroom activities stimulate their interest in the subject. In the interviews, many learners affirmed their belief that motivation is very important for accounting because the subject is complex, and the work is difficult. They also seemed to feel strongly that

motivation is an important factor in not dropping the subject. However, crucially the teacher was identified as someone who needs to encourage the learner to do the activities and actually believe they can do it. With regard to choosing classroom activities that stimulate learners' interest in accounting, a large percentage of the teachers asserted that they do this. Stimulating interest in a subject is a critical motivator for learners who want to learn.

An important action that is linked to motivation is encouragement by the teacher. Some reassuring findings of the teachers' questionnaire are that most of the teachers encourage their learners to question things, and they often encourage their learners to participate in class discussions. These actions are important for developing critical thinking skills as well as building positive classroom relationships. As accounting is a practical subject where active learning and practical application of knowledge are essential to improve metacognitive skills, teachers must plan for these activities. The snowball effect of this could be that the better learners become at applying the skills through persistent practice, the better the possibility that they will experience successful learning and consequently become independent learners.

As trainers in the field of accounting assert only teaching the technical skills is not sufficient to develop a successful accountant. It is also necessary to address broader-based skills and competencies, which include critical thinking. Critical thinking requires various cognitive skills, including interpretation, analysis, evaluation, inference, explanation and self-regulation. Accountants must be competent in these critical thinking skills to be successful in their work, especially in a competitive business environment.

Some of the teacher interviews confirmed that critical thinking skills were incorporated in their accounting classes by analysing problems, problem-solving and allowing learners to give opinions. Teachers giving more difficult exercises and calculations seemed to keep learners challenged. This follows the opinion of Pasewark (2021, p. 138), who stated that developing critical thinking skills will become evident as learners purposefully persist in their problem-solving.

The larger percentage of teachers who indicated that they develop critical thinking could confirm that teachers are willing to present lessons and incorporate strategies that challenge learners' thinking. However, some could be hesitant to do it in practice, maybe in fear of doing it incorrectly or not knowing how to do it. From the qualitative findings, it appeared that learners seem to only have a basic or even any understanding of critical thinking and it is unclear if the teachers incorporate these skills in the accounting classroom. Teachers raised concerns about the time that is

limited to finish all the curriculum content, which results in inadequate time to teach critical thinking skills. However, most of the teachers affirmed that these skills should be stimulated in the classrooms and that it is important for solving problems. They also try to incorporate critical thinking skills by teaching different ways to approach problems. Nevertheless, some felt that the only way learners would pass the subject was to teach according to the test.

Vetter, Schieble and Martin (2021, p. 328) assert that teachers are the primary source to create invitations and opportunities for learners to think critically. Therefore, how learners respond to these opportunities will depend in large measure on the attitudes and the teaching methods and strategies that the teacher adopts. Moreover, many research studies have shown that metacognition, which entails understanding the goals of the learning process, figuring out the best strategies for learning and assessing whether the learning goals are being met, can help learners be academically successful and improve their accounting performance (Darling-Hammond & Richardson 2009; Schleifer & Dull 2009).

Furthermore, some of the learners indicated that they often explore alternative viewpoints when doing accounting activities. This is a very important way to develop metacognitive skills as they need to evaluate different scenarios and comment and give advice. Some of the teachers indicated that they almost always use class discussions that provide opportunities for their learners to think. Carter and Hogan (2013) affirm that a discussion is a good strategy to teach learners to think critically while also giving them criteria to apply in evaluating alternatives. Most of the teachers indicated that they often create class activities that create opportunities for their learners to explore alternative opinions and to listen to the opinions of others. These activities and strategies are very important for the development of critical thinking (Collins & Mangieri 2004).

Questioning was seen as a learning action taken by some of the learners, where some of the learners indicated that they often ask questions in class. This was confirmed during the interviews, where some learners used questioning to understand the content of accounting better. Some of the learners felt comfortable asking questions in the classroom, whereas a few learners raised concerns and expressed their fear of asking questions because of the negative response they get from the teacher and the consequent embarrassment they feel. From the literature, questioning is seen as a teaching strategy that stimulates the development of critical thinking skills, as it will help learners to deliberately generate questions and explore the alternatives and consequences of their actions (Domu et al. 2023, p. 251) and to teach and assess the practical application of questioning skills in accounting. Fortin and Legault (2010) note that it is important to

give learners opportunities to practise questioning skills. This requires teachers to use effective teaching methods that promote the active involvement of learners in their learning. They added that active learning and questioning could:

[B]e achieved through case-study analysis, individual and group projects, problem-based presentations, problem-solving and real-life scenarios, role-play, discussions and simulations. These approaches require [learners] to be actively involved in the learning process through group discussion and self-expression. (Ballantine & McCourt Larres 2007; Farrell & Farrell 2008)

Working through exercises in class and practising homework activities in accounting contribute greatly to learners' success and play a big role in their learning actions. In the qualitative phase, most of the learners confirmed that working through exercises and previous exam papers is the way they prepare for tests and exams in accounting. The literature emphasises (Pickford & Brown 2006) that it is important to create learning environments where learners are continually motivated and encouraged which should be a constant goal of teachers. This includes making the lessons more meaningful and creating activities for the enhancement and development of metacognitive skills for accounting.

Motivating learners to work accurately in accounting and to persist with positive attitudes, as well as creating critical thinking teaching and learning activities, appear to be critical factors for successful learning in accounting. The literature review and empirical study have revealed that successful learning in the accounting classroom is dependent on the development of metacognitive skills, but most important is the positive engagement of the learner with the environment in which the learning takes place.

## ■ Recommendations for improvement

To enable learners to acquire the content knowledge and metacognitive skills needed to be successful in accounting, effective teaching and learning strategies should be utilised in the accounting classroom. Accounting educators should encourage their learners to develop their metacognitive skills for accounting in general, but also specifically within cognitive activities, as these are needed for academic success.

Active learning is goal-directed and driven by curiosity and is very important for problem-solving. This can be achieved through case-study analysis, individual and group projects, problem-based presentations, problem-solving and real-life scenarios, role-play, discussions and simulations. The accounting teacher should incorporate these approaches in the classroom for learners to be actively involved in the learning process and improve their critical thinking, analytical and problem-solving skills.

Being competent in critical thinking skills is essential for accountants to be skilled and effective in their work. Consequently, the accounting curriculum should not only focus on the mastery of formulas and procedures but also focus on an understanding of the interpretation of financial information and the broader implications of these interpretations on businesses. Moreover, critical thinking skills and dispositions need to be developed in the accounting classroom, with a strong focus on persistence. Accounting learners should persevere in problem-solving, work more precisely and accurately, consider others' points of view, generate questions and explore alternatives and consequences of their actions.

In addition, the accounting teacher should, on the one hand, allow learners to be at the forefront of their own learning with an opportunity to acquire analytical and critical thinking skills, while on the other hand, they should develop a sense of control that will lead them to have a greater sense of accountability. A learning environment where learners experience independence should be created, and the decisions that the accounting teacher makes about this can have a great influence on learners' learning and motivation. When learners perceive that their teachers care about them as learners, positive outcomes will most probably be the result.

Metacognition can help accounting learners to be academically successful and has the potential as a learning skill that can serve to improve accounting education.

## ■ Limitations and further research

The research was conducted with accounting teachers and learners, and therefore, I identified the following limitations. The study was conducted only in the Vaal Triangle area of the Gauteng province. As a result, the findings based on this research study might be seen by some to be one-sided and not representative of the views of most accounting teachers in South Africa. Although the response rate was high for the quantitative phase, I had trouble finding more accounting teachers to participate in the qualitative phase, as there were very limited teachers at each school teaching accounting. Only 12 teachers completed the questionnaire and six participated in the interviews. Some teachers failed to complete the questionnaire fully. This resulted in the number of teacher responses in some of the analyses being inconsistent.

## ■ Conclusion

The purpose of the study was to explore how metacognition and motivation influence classroom environments to enhance successful

learning in accounting. The metacognitive skills needed, as well as the motivation of learners in order to create positive classroom environments necessary for successful learning in accounting, were investigated. The research questions have been explored from which critical thinking, metacognitive skills, learning actions and motivational practices influencing classroom conditions for successful learning were identified and discussed. These findings have led to recommendations that could improve the practice of successful learning in the accounting classroom. From this, suggestions were made on how accounting teachers and learners can improve their teaching and learning conditions to experience successful learning. The development of metacognitive skills in the accounting classroom may lead to increased SDL, improved pass rates and enhanced academic performance in accounting if the learners are motivated and feel safe in the learning environment.

# Problem-centred mathematics learning in Grade 2: Enhancing metacognitive thinking

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## ■ Abstract

The current poor standard of mathematics education in South Africa is often attributed to ineffective teaching strategies in the foundation phase that fail to support learning with understanding. A problem-centred learning (PCL) approach reportedly supports metacognitive thinking that promotes mathematics comprehension. This chapter therefore examines how PCL can be implemented in Grade 2 to support metacognitive thinking for enhanced mathematics understanding by learners. A three-phase action research project collected data from four Grade 2 teachers, who reflectively developed and implemented PCL strategies. Data comprised focus group discussions implemented before and after each of the two micro-cycles as well as an open-ended questionnaire completed by the participants at the outset. A metacognitive lens was applied to analyse and interpret the data collected through the three action research phases to understand how PCL principles play a role to support metacognitive thinking. Although teachers agree with the literature supporting PCL in mathematics to encourage metacognition, the data suggest participants struggled to adopt PCL principles, limiting their learners' metacognitive thinking. Leaning towards direct math instruction, insufficient PCL and pedagogical expertise, and teacher attitudes towards collaborative problem-solving math education were significant variables. Guidelines from the data indicate principles needed to direct a change to PCL mathematical instruction in foundational grades.

## ■ Introduction

The 2019 Trends in International Mathematics and Science Study (TIMSS) ranked South Africa second from bottom in mathematics performance out of 39 nations (Mullis, Martin, Foy, & Arora 2020, online). The Department of Basic Education (DBE) report, 'Action Plan 2014 – towards the realisation of schooling 2025' (DBE 2011, p. 1), acknowledges that primary teachers' subject knowledge and teaching abilities must be improved. Education experts express their concern about the current teaching crisis in South Africa (Du Plessis & Letshwene 2020, p. 69; Spaul 2015, p. 34; Taylor 2013, online). The current poor standard of mathematics education in South Africa is often attributed to ineffective teaching strategies in the foundation phase, which have critical consequences for the learning of more formal mathematics (Feza 2014, p. 11; NEEDU 2013, online; Spaul 2015, p. 35; Taylor 2013, online). The literature further emphasises the central role that problem solving plays in the effective learning of mathematics (Anthony & Walshaw 2009, p. 147; Divrik, Pilten & Taşç 2020, p. 288; Doorman et al. 2019, p. 149; Schoenfeld 2016, p. 5; Yopp et al. 2019, p. 5). The available literature shows that the successful facilitation of a

problem-solving approach to the teaching and learning of mathematics increases mathematical understanding through the application of metacognitive thinking, which can have a significant impact on learners' later mathematical abilities (Divrik et al. 2020, p. 301; Güner & Erbay 2021, p. 728). This argument motivated the investigation into the way problem-centred learning (PCL) can be implemented in the foundation phase in North West province in South Africa, to support metacognition.

## ■ Background and problem statement

As of 2013, South Africa lacks nationally representative data on mathematics learning outcomes at the foundation phase. Learner assessment, a crucial component alongside curriculum and pedagogy, constitutes one of the three pillars of mathematics education in the country, and the TIMSS serves as a key component for international comparative assessment within this pillar. The earliest primary school grade in which recent and dependable national data are available is Grade 5 through the TIMSS (Reddy et al. 2020). From these results, it is clear that Grade 5 learners struggle with foundational concepts of number, which is a foundation phase proficiency (Spaull, Courtney & Qvist 2022).

South Africa has witnessed concerted efforts to enhance foundation phase mathematics teaching through initiatives such as the implementation of innovative teaching methods and the integration of technology in classrooms (Morrison et al. 2023, p. 316). Government-led programmes and collaborations with non-profit organisations have sought to address educational disparities and improve foundational numeracy skills among young learners (Graven & Venkat 2023, p. 12; Taylor 2021, p. 5). Despite these attempts, educationists still blame foundation phase teachers who are held responsible for laying solid foundations for mathematics with learners in the early school grades (Mabena, Mokgosi & Ramapela 2021, pp. 458–459). MacFarlane (2013, online) cites multiple works that suggest South African learners' arithmetic incompetence begins in the foundation phase but only appears in later grades. Feza (2014, online) and Taylor (2013, online) agree with this.

A lack of problem-solving abilities contributes to learners' low arithmetic performance (Aunio et al. 2019, p. 66; Bayaga, Ndamase-Nzuzo & Bossé 2022, p.183, DBE 2014, online). Problem solving is crucial to learning all mathematics (Dolmans et al. 2005, p. 734; Giganti 2007, p. 15; Stein, Grover & Henningsen 1996, p. 455). Dolmans et al. (2005, p. 735) found that problem-solving-focused teaching strategies can better prepare learners for future learning because they are based on four learning principles: constructive, self-directed, collaborative and contextual learning.

Foundation phase teachers must create a strong basis for young learners to acquire mathematics meaningfully (Feza 2014, online; Taylor 2013, online). Meaningful mathematics instruction should encourage self-directed and collaborative problem solving (Anthony & Walshaw 2009, p. 149; Bishara 2021, p. 93). Teachers must also improve problem-solving skills, so learners feel confident in their mathematics ability (Kaitera & Harmoinen 2022, p. 115; Muthivhi 2009, p. 68). Successful problem-centred mathematics learning requires learners to be aware of their thought processes as they solve problems (Divrik et al. 2020, p. 288). Metacognition occurs when they actively regulate their problem-solving actions (Divrik et al. 2020, p. 293; Schoenfeld 2020, p. 359). Problem-centred mathematics relies on metacognition as a higher-order thinking ability (Daher & Hashash 2022, p. 1272; Güner & Erbay 2021, p. 717).

The lack of research on metacognition strategies for younger learners suggests that this skill is not anticipated by foundation phase learners. Van Aswegen, Swart and Oswald (2019, p. 2) recommend teaching and modelling metacognition to young learners before they 'form ineffective habits and beliefs about themselves as learners'. Chen, Wu, Wu, Shangguan and Li (2022, p. 2) add that '(m)etacognition can be successfully taught in different education stages ranging from primary school to university, and it is critical for improving thinking skills'. Supporting metacognition as a 21st-century learning capacity in self-directed problem solving (Rehman et al. 2023; Sarmishtha 2024, p. 6) might improve learners' future performance. Given South Africa's educational and contextual constraints, we believe teachers should be empowered to find creative means to support metacognitive thinking from an early age. This necessitates various forms of knowledge.

Teachers need mathematical subject knowledge, pedagogical knowledge and pedagogical content knowledge to scaffold mathematics problem solving (Darling-Hammond et al. 2020, p. 97). In addition, teachers' beliefs about what mathematics is and how it should be taught (Mainali 2022, p. 412), their metacognitive skills and knowledge (Hart & Memnun 2015, p. 70), and their beliefs about the value of a problem-centred approach to mathematics teaching (Ernest 2006, p. 67) will determine how they facilitate metacognitive learning.

The majority of teachers value problem solving in mathematics which has been studied from different angles. Two of these approaches, namely, inquiry-based learning (IBL) (Divrik et al. 2020, p. 288; Ferguson 2010, p. 54) and project-based learning (Rehman et al. 2023), are linked to Dewey's (1916) focus on learning by involving real-life problem-solving. Most other problem-solving approaches also value the focus on real-life problems such as realistic mathematics education

(RME) (Neufeld & Barrows 1974; Yuanita, Zulnaldi & Zakaria 2018), PCL (Apriliana, Handayani & Awalludin 2019; Cobb et al. 1991; Ridlon 2009), project-based learning (Markula & Aksela 2022; Rehman et al. 2023) and problem-based learning (PBL) (Dolmans et al. 2005, p. 736; Neufeld & Barrows 1974; Tawfik et al. 2021). Whereas these terms are often used interchangeably to refer to learning with a focus on active learner engagement through the solving of problems, a closer look reveals distinct characteristics of each approach. RME, originally coined by Freudenthal (1971, p. 413), predominantly focuses on solving problems situated in real-world contexts. Not much research has been conducted on PCL since the earlier work by researchers such as Cobb et al. (1991), Cobb, Yackel and Wood (1989) and Ridlon (2009). This approach never took off as a mainstream approach to mathematics education. However, based on the available literature, PCL allows for more guidance by the teacher, which makes it suitable for younger learners (Cobb et al. 1989, 1991; Ridlon 2009). Since the late 20th century, research with a focus on mathematics problem solving has been largely dominated by PBL, initially suggested in the field of medical education by Neufeld and Barrows (1974, p. 1042). Problem-based learning has been widely accepted in different educational fields to support critical thinking (Yew & Goh 2016, p. 75). While this approach also emphasises the solving of authentic problems where learners are in control of their own learning, Tawfik et al. (2021, online) explain that PBL puts emphasis on open-ended and ill-structured problems that provide for open enquiry. Problem-based learning further requires learners to reflectively solve an array of problems and often include problem solving with peers (Tawfik et al. 2021, online). Although there is strong support for PBL in the literature, successful implementation requires specific teacher competence and knowledge of the underlying principles, including the facilitating role of the teacher, especially in large groups (Hmelo-Silver 2004). Younger learners who have not yet developed the necessary self-directed learning (SDL) skills to solve ill-defined problems independently could be overwhelmed, which could lead to cognitive overload and lower mathematics self-efficacy beliefs (Hmelo-Silver 2004; Hung, Jonassen & Liu 2008; Westwood 2011). Hmelo-Silver points out that younger learners have difficulty applying metacognitive strategies which may hamper effective PBL, especially where teachers lack PBL pedagogical skills. Westwood (2011) further heeds that:

'[Y]oung children at the elementary stages of mathematics do not yet have an adequate base of number knowledge and skills from which to draw in order to solve challenging word problems. Such knowledge, and such automaticity in skills, can best be established through direct teaching followed by abundant practice.' (p. 10)

Considering the mathematics competence level of Grade 2 learners, the context of the school where teachers are challenged by the relatively large classes and diverse learners who are mostly from poor socio-economic background, and teachers' lack of PBL principles, this approach was regarded as a risk to mathematics learning outcomes. Problem-centred learning, as a more adaptable approach to mathematics problem solving, and which recognises the teacher's scaffolding role in helping novices master arithmetic and problem solving, provided a more suitable framework to examine how a problem-solving approach to mathematics learning in Grade 2 (8 years old) may enhance metacognition.

A participatory approach to investigating mathematical problem-solving facilitation is necessary as teachers' teaching methods are shaped by their teaching context (Stoll, Fink & Earl 2003, p. 8). Hearing teachers' voices helps to bridge research and practice (Hine 2013) and can assist in providing them with PCL knowledge and abilities.

The motivation for the study is firstly directed at the search for ways to promote meaningful learning of mathematics in the foundation phase and, secondly, to fill a gap in the research. Suseelan, Chew and Chin (2022, p. 1003) and Klang, Karlsson, Kilborn, Eriksson and Karlberg (2021, p. 3) call for more research on teaching approaches to support problem-centred learning (PCL) in mathematics. Stetson-Tiligadas (2018, p. 45) indicates a gap in research on meaningful problem-centred teaching strategies, with a specific focus on the way in which constructive, self-directed, collaborative and contextual learning works or does not work, and what conditions are necessary for effective problem solving.

Descriptive statistics on the standard of mathematics confirm that learners do not master mathematics properly and that a proper foundation for mathematics is lacking (Spaull 2015, p. 36). The literature examined converges about the value of supporting metacognitive learning in a problem-solving approach. Stipulating metacognition as a core principle of PCL, the expectation is that investigating PCL strategies for mathematics teaching in Grade 2 will also strengthen the case for supporting metacognitive thinking. Rendering guidelines for PCL, relevant for Grade 2, was thus expected to inform meaningful problem solving supporting deep learning through metacognitive thinking by these young learners. The aim of this study, therefore, is to understand how to implement PCL in Grade 2 to enhance metacognitive thinking in mathematics.

The following research question directed the study:

How can PCL be implemented in Grade 2 to support metacognitive thinking in mathematics?

## ■ Literature review

As grounding for the investigation, literature on meaningful mathematics education is firstly explored with a focus on the main determinants that play a role in mathematics teaching and learning outcomes. Secondly, PCL as an approach and its principles are unpacked.

## ■ Meaningful teaching–learning of mathematics

Learners should experience mathematics as meaningful in their real lives, where we use it as part of our daily activities to make sense of the world (Bosman et al. 2015), and to assess reality, solve problems and make predictions (Siemon et al. 2013). Understanding mathematics' basic purpose helps teachers create a vision of teaching that empowers learners for the future (Ernest 2006, p. 69). Thus, a vision of mathematics' usefulness should guide all mathematics instruction for meaningful, sustainable learning.

Instruction in mathematics that is not developmentally appropriate causes young learners to struggle with the subject (Clements, Lizcano & Sarama 2023, p. 3; Schoenfeld 2016, p. 32; Sullivan, Knott & Yang 2021, p. 94). Koskinen and Pitkäniemi (2022, p. 8) and Westwood (2011, p. 8, 10) argue that learners are more motivated to engage in mathematics when teaching helps them to understand the focus of learning rather than mindless memorising of procedures and facts. Mohamed, Khalil and Awaji (2023, p. 4) agree that this kind of teaching encourages introspection and dialogue that support understanding. Meaningful teaching of mathematics involves learners in dynamic problem-solving tasks with a focus on real-world contexts, the use of concrete manipulatives, with less focus on worksheets and traditional classroom education (Kaitera & Harmoinen 2022, p. 112; Koskinen & Pitkäniemi 2022, p. 8; Westwood 2011, p. 10). When learners are supported to constructively link new knowledge to prior knowledge and can relate mathematics to their real lives, they are more likely to fully engage and apply intrinsic motivation to find solutions for problems posed (Westwood 2011, p. 6). Koskinen and Pitkäniemi (2022, p. 8) emphasise that this kind of teaching requires skilled teachers who are able to choose the most relevant content and design problems that learners can relate to. Choosing learning tools and focusing learners' communication on what is important to solve the problem, and creating an 'affectively favourable classroom atmosphere' are among the roles of teachers to successfully implement any problem-solving approach (Koskinen & Pitkäniemi 2022, p. 11). Smith and Mancy (2018) emphasise the role of group-work environments to support meaningful learning of mathematics, through the shared thinking processes, with reference to both procedural

and declarative knowledge of mathematics. When learners are supported to regulate their own cognitive processes, metacognition supports logical thinking, leading to meaningful learning.

## ■ The role of problem-centred learning for meaningful learning of mathematics

As mentioned earlier, not much research with a focus on PCL has been conducted. However, the principles of PCL suggested by Ridlon (2009) provide a framework for the implementation of a problem-solving approach for Grade 2 learners. Therefore, the role played by PCL in the study was mainly informed by the work of Ridlon (2009). Ridlon (2009, p. 189) defines PCL as meaningful collaborative problem solving with the freedom to suggest different strategies and share ideas and thought processes. This approach therefore provides a problem-solving approach that can be adapted according to the specific context and educational needs.

Asmar and Hafiz (2020, p. 6215) explain the active role of the learner in PCL, when they 'identify a problem, analyse it, reconstruct an argument, conduct an evaluation so that they can solve the problem'. These authors agree with Ridlon (2009, p. 194) when they highlight that PCL provides learners the opportunity to construct their own knowledge leading to better understanding and confidence in their mathematics capabilities.

Ridlon (2009, p. 189) believes PCL enhances learners' mathematical abilities and attitudes and can be effectively utilised in any curriculum, provided the teacher understands and applies its components appropriately and efficiently. Ridlon (2009, p. 190) also found PCL improves communication abilities. This notion is also supported by Cobb (1991, p. 26), who emphasises the role of language in PCL that is based on socio-constructivism, where the teacher fulfils a supporting role by engaging with the learners. This role poses specific challenges to the teacher. Effective PCL involves regular, intelligent and inclusive teacher-learner communication (Ridlon 2009, p. 190). Problem-centred learning requires learners to solve problems in groups and debate their answers, which boosts cognition. Collaborative group communication also improves learning (Machmud 2019, pp. 1-11). While communication is vital for learning, learners should be given more questions that challenge their mathematical thinking rather than rote learning of processes (Biccard & Wessels 2011, online). In PCL, teachers thus play a core role in the type of questions and guidance given to learners that will determine their development as active communicators to support metacognition and a deep understanding of mathematics.

Problem-centred learning also fosters self-directedness by making learners feel confident enough to master mathematics on their own

(Ridlon 2009, p. 193). Knowles (1975, p. 3) states that SDL motivates learners because they are driven by self-worth, curiosity, achievement and success. Supporting SDL in mathematics could motivate sustained meaningful mathematical learning and prevent learners from dropping mathematics as a subject as soon as the system permits.

Over the four years between 2008 and 2011, the proportion of South African learners who did not take pure mathematics (as opposed to mathematical literacy) dropped from 56% to 45% because more learners thought mathematics was too difficult (Spaull 2015, p. 37). If incorporated into daily pedagogical activities meaningfully, PCL may boost confidence in one's mathematical ability and enhance the number of school graduates who can study mathematics at university level.

## ■ Principles of problem-centred learning

The PCL principles of Ridlon's study were important because other publications alluded to them (Asmar & Hafiz 2020; Biccard & Wessels 2011; Machmud 2019; Maree et al. 2005). These principles informed the data that were analysed and interpreted in the empirical investigation. This research applies Ridlon's PCL concepts of metacognition, collaborative learning, reflection and teacher facilitation (Ridlon 2009, p. 193). This research emphasises metacognition based on collaborative learning and reflection, and how the teacher facilitates PCL via metacognition. The relevance of problems to the learner's real-world situation was included as a fifth principle. The research agrees that real-world problems assist learner understanding of how problem solving applies to their lives.

## ■ Metacognition

Flavell (1979) explains that metacognition consists of both monitoring and regulation of one's thought processes. He defines metacognition as follows:

In any kind of cognitive transaction with the human or non-human environment, a variety of information processing activities may go on. Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in service of some concrete goal or objective. (p. 232)

Efklides (2006, p. 5) differentiates metacognitive knowledge, metacognitive skills and metacognitive experiences. Metacognitive knowledge enables learners to understand their own and other's thinking which guides their interpretation of information and informs and controls the decisions they make. Metacognitive skills or strategies as 'procedural knowledge', enable the learner to control their learning processes. Metacognitive experiences, which operate in the working memory, are associated with affective

experience and involve metacognitive feelings. Efklides emphasises that metacognitive experience can have positive outcomes such as feelings of knowing and confidence or evoke negative feelings such as failure or incompetence. These feelings will influence the application of metacognitive knowledge and metacognitive skills.

According to Bloom's Taxonomy (Krathwohl 2002, p. 213), learning focuses on analysing, evaluating and designing one's own strategies to solve problems, so understanding one's own thought processes can help develop higher-order thinking levels.

Metacognition must be distinguished from cognition to understand its significance in PCL. Downing et al. (2009, p. 611) define cognition as the solution and metacognition as the personal process. Metacognition helps people identify the proper method and tackle problems strategically (Van der Walt 2006, p. 27). Metacognition, which helps learners understand mental processes (Graaff 2005, p. 13) and is crucial to academic achievement, is perhaps even more essential in life, as reflecting on one's thoughts aids in making better and wiser judgements in all areas (Larkin 2010, p. 23).

A learner may reflect, evaluate and derive inferences from metacognition, thus reflecting on their cognition metacognitively (Downing et al. 2009, p. 612). Metacognition also allows meaningful application of previous learning. To solve difficulties, learners must understand how their brains work and how they remember, learn and solve problems (Downing et al. 2009, p. 613). Metacognition helps learners think critically and apply information, moving away from prescriptive learning (Cobb et al. 1991, p. 3). Metacognitive learning thus helps preserve information in long-term memory for subsequent use to handle comparable issues.

According to Flavell (1979, p. 908), metacognition helps learners comprehend their own and others' mental processes, making it essential for effective collaborative learning. The learner may focus on modifying his or her thinking, as needed, and reflect on other learners' reasoning and cognitive processes. Metacognition allows learners to study others' mental processes and consider alternate techniques, expanding their problem-solving possibilities. Scheibe, Was, Dunlosky, and Thompson (2023, p. 1) link metacognition to mathematics problem solving. But they caution that:

Metacognitive monitoring can hinder accurate mathematical problem solving when it is task-irrelevant, but task-relevant metacognitive experiences can help with control decisions like checking work, considering plausibility of an answer, and considering alternate strategies. (p. 1)

These authors note that mathematics anxiety might hinder metacognitive experiences in mathematical problem solving and even cause learners to forego metacognitive learning that could have helped them.

Therefore, teachers must know how to facilitate metacognitive learning, particularly in the foundation period, when improper instruction might have a long-term effect on mathematical confidence. Research shows that collaborative learning reduces mathematics anxiety (Lestari et al. 2019, pp. 15–32; Sadeghi, Shahvarani & Behzadi 2021, p. 129) and supports metacognitive learning in mathematics problem solving.

Pedagogical Content Knowledge (PCK) principles are interdependent, therefore supporting one affects the others. Although all five principles are important in PCL, this chapter focuses on metacognitive thinking as a result.

## ■ Collaborative learning

The terms collaborative learning and cooperative learning are often used interchangeably in the literature. Reports on PCL principles often use the term cooperative learning, an approach that emphasises learner interdependence (Yang 2023, p. 2). Johnson and Johnson (1999, p. 73) describe cooperative learning as ‘the instructional use of small groups so that learners work together to maximise their own and each other’s learning’. Yang (2023) points out that collaborative learning is generally viewed as an:

[U]mbrella term for various instructional approaches to small group learning, including but not limited to cooperative learning, team-based learning, peer tutoring, study groups, project-based learning, problem-centred learning, and learning communities. (p. 3)

The PCL approach implemented in this study rather employed collaborative learning that tends to be less structured (Yang 2023, p. 4) and allowed learners to solve problems in a self-directed way in small groups. Collaborative learning was inspired by Piaget and Vygotsky. A socio-constructivist and socio-cultural approach to learning leads to reflection (Krause & Starka 2010, p. 255). Chung Chin, Zakaria, and Daud (2010, p. 272) found that collaborative learning improves mathematics and social abilities. These writers also note that collaborative learning affects long-term memory, attitude to mathematics and self-esteem.

Slavin (1987, p. 45) emphasises collaborative learning’s cognitive, social and emotional effects. Discussing the information, explaining how the work will be performed, listening, trying to discover answers and helping each other are all part of the learning process.

Collaborative learning goes beyond sharing tools and helping one another but engages learners in the learning process to help each learner learn (Krause & Starka 2010, p. 256). In collaborative learning, personal objectives, responsibility and social skills must be established (Barham 2011, p. 8).

Different authors disagree on collaborative group composition. Certain authors propose diverse groups; however, Krause and Starka (2010, p. 257) recommend homogenous groups because stronger learners might dominate slower learners.

The literature links social learning with metacognition (Alzahrani 2017, p. 75; Jayapraba 2013, p. 1309). Collaborative learning allows learners to communicate their problem-solving approaches and cognitive processes while expressing their opinions to others, according to Jayapraba (2013, p. 1309). By discussing classmates' approaches, learners assess themselves. Verbalising knowledge also lets teachers measure learners' comprehension. Although Alzahrani (2017, p. 476) refers specifically to cooperative learning, this author highlights that encouraging social interaction assists metacognition. This author notes that cooperative learning allows self-regulation while evaluating alternative perspectives. Collaborative learning helps learners acquire social skills like 'listening, contributing and sharing, and it also impacts upon their individual ways of thinking', which develops metacognition (Larkin 2010, p. 23).

## ■ Reflection

Dewey (1917/©1933, p. 3) defines reflection as 'the kind of thinking that consists in turning a subject over in the mind and giving it serious and consecutive consideration'. Considerations of 'any belief' encompass personal and other perspectives. Dewey (1983, referenced by Rodgers 2002) emphasises shared reflection on experience and claims that learning occurs when learners engage with their environment, including others.

According to Skinner (2010, p. 15), attentive reflection enhances learning, and both learners and teachers must reflect throughout PCL. Krause and Starka (2010, p. 259) also describe reflective learning as intentional and regulated metacognition that aids topic comprehension. The link between reflection and metacognition is verified by Efklides (2011, p. 6). Dewey believed that schooling should educate learners on how to reflect so they may use it in everyday life (Artzt, Armour-Thomas & Curcio 2009, p. 5). To get a deeper understanding, learners must be encouraged to reflect on their learning (Ash & Clayton 2009, p. 25).

## ■ The teacher as facilitator

The teacher creates the context for metacognitive thinking in PCL (Daher & Hashash 2022, p. 1274; Schoenfeld 2016, p. 37). The teacher who acts as a facilitator focuses learning on relevant issues and supports independent problem solving, which improves mathematical knowledge and produces

autonomous problem-solvers (Ridlon 2009, p. 195). The learner-centred approach involves the teacher stepping aside and only helping learners when needed. But Goodyear and Dudley (2015, p. 274) advise against seeing the teacher as a facilitator who is passive in the teaching-learning process. To support and extend learning, the learner-centred approach requires the teacher to be directly involved in the learning process through a variety of direct and indirect teaching strategies and dialogue (Goodyear & Dudley 2015, p. 275). These writers advocate for teachers to be ‘activators of learning’ who generate new learning possibilities.

A facilitating role implies imparting information and creating a classroom climate that encourages active learning with comprehension. The facilitating teacher plans and delivers individual and group activities that encourage independent mathematical thinking for improved comprehension, thinking, and reasoning (Doyle 2007, p. 246). As a facilitator, the teacher supports constructivist and collaborative learning, learner reflection and metacognition.

## ■ Metacognitive lens

Interest in using a metacognitive perspective to implement PCL in mathematics education has been on the rise in recent years. The principles of PCL, namely, collaborative reflective learning, while the teacher acts as a facilitator of real-world problem-solving experiences (Ridlon 2009, pp. 191–193), often emerge in the literature with a focus on metacognition. There is evidence that group work improves learners’ ability to reflect on their own learning (Smith & Mancy 2018, pp. 14–36). Learners may have a more thorough comprehension of mathematical concepts and processes by working together and hearing different points of view (Boaler 2022, p. 24). Metacognitive thinking also includes reflective thinking, which helps learners assess their own learning and focus on areas where they may make the most progress (Antonio 2020, pp. 467–483).

Promoting metacognitive thinking in PCL relies heavily on the facilitatory role of the teacher. Open-ended questions that prompt learners to reflect on their own learning are one way in which teachers may guide and assist learners in developing their metacognitive abilities (Mandouit & Hattie 2023, p. 101). Last but not least, issues with an emphasis on real-world applications might encourage learners to use metacognitive strategies as a lens (Boaler 2022, p. 24).

Overall, using a metacognitive lens to implement PCL in Grade 2 mathematics may greatly improve learners’ achievement. Educators may aid learners in developing metacognitive abilities and becoming more

successful 21st-century learners by emphasising collaborative learning, reflection, the teacher's role as facilitator and a focus on issues with real-world relevance.

## ■ Research design and methodology

A qualitative research approach was the most appropriate approach to explore answers to the research question as the study explored a social phenomenon (Merriam & Tisdell 2015, p. 5) and aimed to hear the voice of the participating Grade 2 teachers (hereafter referred to as participants) informed by their lived experiences (De Clercq 2013, p. 31). The personal values that both the researcher and participants bring to the study are acknowledged (Creswell & Creswell 2018, p. 182). This approach is particularly relevant in this study where the researcher worked collaboratively with participants in an action research process in the search for suitable PCL teaching strategies for mathematics. While the research design determines the data collection method and data analysis (Nieuwenhuis 2007b, p. 70), the choice of the research design is determined by the research paradigm grounded in the researcher's paradigmatic assumptions of how the social world should be explored.

## ■ Research paradigm

The study rests within the constructivist paradigm, an approach that falls within the interpretivist philosophical orientation (Guba & Lincoln 1994, p. 105). Social constructivist epistemology as a theoretical framework within the research paradigm was adopted, which argues that an increase in knowledge is a cumulative process during which people gain new insight by adding new shared knowledge to existing knowledge (Burrell & Morgan 1979, p. 6).

Nieuwenhuis (2007a, p. 47) indicates that an interpretivist orientation to the investigation of a phenomenon aims to better understand the phenomenon by examining the meaning that people attach to it. This orientation is based on the sociology of regulation and follows a subjective approach to the subject being investigated (Burrell & Morgan 1979, p. 8). The sociology of regulation focuses on explanations of the status quo and of how to deal with needs and problems. An interpretivist approach to the investigation aims to understand and interpret teachers' experiences of suitable teaching strategies to support PCL. Following this understanding, suggestions can be made for strategies to support self-directed metacognitive reflection in a problem-centred approach to Grade 2 mathematics education.

## ■ Action research

McNiff (2017, p. 9) describes action research as a ‘way for all people to take action in their personal and social situations with a view to improving them’. Action research has become popular among persons with an interest in improving teaching and learning processes, with a focus on the effect of teaching on learning outcomes. Benefits of action research within the teaching context include the generation of practice knowledge and the consequent improvement of the well-being of the person and community (Reason & Bradbury 2008, p. 12), the improvement and transformation of practice (Cohen, Manion, & Morrison 2007, p. 5; Koshy 2010, p. 20), a better understanding of the influence of teaching on learning (Whitehead 2009) and a way to bridge the gap between theory and practice (Cohen 2011, online).

Coghlan and Shani (2020) highlight action research as an integrative approach that incorporates first-, second- and third-person practice or enquiry. They advocate for the inclusion of abductive reasoning to link these practices. This integration enhances the value of action research for both practice and theory by connecting the researcher’s subjective enquiry (first-person), the collaborative dynamics between the researcher and participants (second-person) and the meaning of the generated knowledge for external entities (third-person) (Coghlan & Shani 2020).

Considering the mentioned advantages, action research was an appropriate method to investigate strategies to support metacognition in PCL of mathematics, especially because the study aimed to contribute to the deeper understanding and improvement of mathematics teaching and learning in Grade 2 through metacognition. Koshy’s (2010, p. 21) view of action research as a practical and problem-solving approach to research, where a deeper understanding and improvement of practice is sought over a certain period of time, emphasises the relevance of this research methodology for this study. McNiff (2017, p. 12) explains that the action research cycle begins with a problem, followed by developing a plan as a solution. The plan is implemented in practice, followed by observation and reflection by the participants. Through discussion, participants come to an agreement on the necessary adjustments that must be made to improve whatever is the focus of the research as appears to be necessary. The adjusted plan is implemented again in a successive cycle. The cycles can then be repeated continuously to refine the solution.

In this study, the aim of the first phase (experiences before implementation) was to collect data on the participating teachers’ prior knowledge of metacognition and problem solving with a specific focus on

these constructs in the context of PCL. It concludes with the participants' suggestions for supporting PCL teaching strategies for implementation in a mathematics lesson.

Phase 2 focuses on participants' experiences during the action research process, which includes the implementation of the two action research cycles. Each cycle consists of the implementation and observation of the planned PCL lesson, collaborative reflection on metacognitive thinking in the PCL teaching strategies and concludes with the adaptations of PCL teaching strategies to be implemented in the next cycle.

Phase 3 focused on a retrospection of the data collected through the previous phases and PCL principles reported in the literature. All three phases are therefore logically linked.

## ■ **Context of the school and background of the participants**

The action research was implemented at a dual medium school in North West province, attended mostly by learners from previously marginalised communities. The primary school counts approximately 1800 learners and has a teacher-learner ratio of approximately 42:1. Where this school is classified as quintile 3 public school, school fees are determined by the income of the learner's parent or legal guardian; however, a large percentage of the parents qualify for exemption of school fees which makes the school largely dependent on the department for funding.

The four Grade 2 teachers who participated were assigned pseudonyms and referred to as P1\_Frieda\_19 years teaching experience, P2\_Elsa\_6 months teaching experience, P3\_Susan\_3 years teaching experience and P4\_Mary\_3 years teaching experience in the reporting of the findings. Three of the four participants were relatively young (between 23 and 32 years old) with experiences varying between six months to three years. With 19 years' experience, P1\_Frieda\_19 years teaching experience had the most teaching experiences which also showed in the way she contributed rich data. P1\_Frieda\_19 years teaching experience completed a higher education diploma in foundation phase education, while the other three participants hold a BEd Foundation Phase qualification.

## ■ **Study population and sample**

The study focused on PCL strategies as implemented in Grade 2, and therefore, Grade 2 teachers were considered as the study population. Only one school was selected because the number of teachers (9) teaching Grade 2 was considered sufficient. Participants were selected by means of

non-probability, convenient and purposive sampling. All nine Grade 2 teachers from the school were invited to participate in the action research process. Six teachers agreed to voluntarily participate of which two did not arrive for the research activities. The number of participants was therefore determined by the number of willing Grade 2 teachers. The specific purpose was on PCL strategies for mathematics in Grade 2. On this level, learners already have the basic knowledge and skills (such as reading, writing and basic mathematics) to benefit from PCL.

## ■ Data collection

Considering the aim of the study, namely, to come to an in-depth understanding of the participants' views and experiences of metacognition through PCL, the first author kept a researcher journal to document observations and aspects emerging from the action research process. Focus groups, participant reflection journals and open-ended questionnaires were also used as data collection tools, which, according to Nieuwenhuis (2019, p. 57), are typical of qualitative research.

The researcher journal enabled the first author to incorporate reflexive thinking during the action research phases with a focus on past experiences and how past experiences may influence the interpretation of the data. The journal also provided a way to record own learning and ideas that may inform the development of codes and themes (Creswell & Creswell 2018, p. 184).

Focus groups promote spontaneity in a social environment and motivate the sharing of perceptions, ideas and experiences to render deeper and richer data than individual interviews (Gundumogula 2020, p. 301). Participants expanded on each other's ideas and comments and interactions focused on establishing a shared rather than individual view of the way PCL supports metacognition.

Open-ended questionnaires provided an opportunity to generate data on aspects that participants often do not readily share during focus groups such as attitudes, values and convictions (Mohajan 2018). At the outset, participants were asked to complete open-ended questionnaires with a focus on their experiences as part of the action research process. Individual reflections on the questions further provided participants who did lack the confidence to share their thoughts in the focus group, to open up about their experiences.

## ■ Ethical aspects

Consent was obtained from the Department of Education (Department of North West Province, Dr Kenneth Kaunda District), the school principal,

involved teachers and parents as well as from the governing body before carrying out the study. Ethical consent was obtained from North-West University's (NWU) Faculty of Education Sciences Research Ethics Committee (EduREC), with ethics number NWU-00138-16-A2. Although the purpose of the video recordings of the lesson presentations was to focus teacher reflections on the PCL strategies only, the parents were asked to sign consent that their children may be video recorded with the precondition that the recordings will not be distributed but deleted after completion of the study. Participation was voluntary, and participants were aware that they could withdraw from the study at any time. Participants were also reassured that they may withdraw from the study without any consequences. They were also assured that all data collected from them would be anonymised in the reporting of the findings. Therefore, pseudonyms are used in the discussion of the findings.

## ■ Trustworthiness and reliability of the study

The reliability and credibility of a qualitative study refer to the reproduction of the accuracy of the data in the context within which the data is collected (Nieuwenhuis 2019, p. 60). Generalisation of findings is not an objective of qualitative studies (Korstjens & Moser 2018, p. 120), and we do not claim that findings can be applied to the broad population of all foundation phase teachers. However, an explanation of the context of the school and participants provides an opportunity to determine applicability to a similar context.

Reflectivity, which is ensured because of the reflective journal used, contributes to the credibility in qualitative studies (Finlay 2003, p. 5) and involves the researcher's explicit acknowledgement of ongoing active involvement in the research process (McMillan & Schumacher 2010, p. 12). For this study, it is acknowledged that the researcher's own experience, assumptions and values could have played a role in the course of focus group discussions and the analysis of data. The researcher had to constantly be aware that her own beliefs, of what suitable PCL strategies in Grade 2 should look like or do, did not have an influence on the data and findings. It was therefore important to focus on the teachers' lived experiences. The video recordings of the focus group discussions also strived to increase the validity and reliability of the interpretations of teachers' input.

As suggested by Denzin and Lincoln (1994, p. 105), the use of multiple data collection methods, namely, focus group discussions, reflection journals and open-ended questionnaires, provided an opportunity to overcome intrinsic bias and to promote credibility by interpreting and comparing the experiences of participants from various angles. Participants'

own words as recorded in their journals, transcribed data collected during focus group discussions and open-ended questionnaires, are quoted to support the interpretation of the data when discussing findings.

## ■ Data analysis

A distinction is made between the data collected in the three connected phases following the time course of the action research process. The analysis specifically focused on the teachers' experiences of PCL teaching strategies as reported by the participants before, during and after the action research process. In line with the constructivist-interpretivist paradigm, the researchers strived to understand the different constitutive elements of the data through an exploration of the relationship between the elements. The data analysis process therefore focused on identifying logical patterns or tendencies related to metacognitive thinking emerging from the data.

McNiff (2017, p. 183) explains that in action research (AR), data should be turned into evidence through three steps namely 'analysing the data, authenticating data and making sense of the data'. She emphasises that these steps are not discrete processes but rather 'act more as a continuum, where each element transforms into and merges with another'. Although the data collection, analysis and interpretation are discussed separately, it should be noted that these steps occurred continuously throughout the phases and the findings on one phase or micro-cycle were expected to inform the actions of the participants and the researchers in the following phases or micro-cycle. Data collection, analysis and interpretation therefore happened in an integrated way based on the cyclic nature of action research (Cohen et al. 2007; Koshy 2010; McNiff 2017, p. 183).

Although the larger study reported on coding related to all principles of PCL, this chapter specifically applied a metacognitive lens, by exploring the influence of the PCL principles, namely, collaborative learning, reflection, the facilitating role of the teacher and a real-life focus of problems, on metacognitive thinking. Abductive reasoning was applied in the analysis of the data. Coghlan and Shani (2020, n.v.) explain that 'abductive reasoning provides a construct through which we can understand how theory develops in action research'. Through abductive reasoning, inductive and deductive reasoning processes, that each plays a significant role in verifying hypotheses, are extended (Lorino 2018, cited by Coghlan and Shani 2020, online). Abductive reasoning provides answers to the question 'What is going on?' because it produces logical explanations for perplexing phenomena as they arise. It is not just an instantaneous revelation but a process. Although the PCL principles influenced the coding process,

‘expected codes’, ‘surprising codes’ and ‘codes of unusual or of conceptual interest’ (Creswell & Creswell 2018, p. 195) also emerged through abductive reasoning.

Video recordings of the focus group discussions were transcribed verbatim while reflective journals were transcribed for coding through the help of a computer-assisted qualitative data analysis software, namely ATLAS.ti™. By applying content analysis, chunks of data that logically relate to the metacognition in the context of PCL were coded. Content analysis is a method to make sense of large volumes of qualitative data by identifying recurring patterns that assist in making meaning of the data from different perspectives (McNiff 2017, p. 185; Patton 2015, p. 65). As suggested by Boeije (2002), continuous comparison of the themes based on the data collected in different phases enabled the researchers to compare positive and negative evidence and findings concerning the way the PCL approach supported metacognitive thinking with the Grade 2 learners.

## ■ Findings

Reported findings according to the three action research phases demonstrate the participants’ actions to revise their strategies informed by previous experiences within their context.

### ■ Phase 1: Before implementation of the problem-centred learning lesson

The principles of PCL and the role of metacognitive thinking in PCL were explained to participants at the onset by the first author. During the first focus group discussion, participants explained the current strategies they used to teach mathematical problem solving. Participants concurred that mathematical problem solving mostly entailed the teacher-designed problems on different levels to match the ability of the three to four ability groups as prescribed by the Department of Education and as set out in the curriculum for mathematics. Each learner received a worksheet according to his or her ability group to complete. Groupwork was mostly understood as dividing learners into the prescribed homogeneous ability groups to accommodate differentiation. P3\_Susan\_3 years teaching experience explained their collaborative problem-solving activities as follows:

‘We already have group teaching... according to CAPS [Curriculum and Assessment Policy Statement], we are supposed to do problem-solving... word problems and stuff like that, once a week. We put the problem on the board and then on a Friday, they should battle with that problem for the week’.

It became clear that, although learners were divided into ability groups to differentiate the level of their tasks, and to enable the teacher to provide

support to learners according to their levels (Cooney & Darcy 2020, p. 3), working collaboratively to solve a problem was not the focus.

Learners may choose to use concrete resources to solve the problems after which the solutions are filled in on the worksheets. Problems mostly involved story sums related to real-world scenarios and served as an opportunity to practise mathematics topics explained by the teachers. The teachers observed and guided the learners while they solved the problems, and worksheets were assessed by the teacher afterwards.

Participants acknowledged that they did not specifically focus on the principles of PCL or metacognitive thinking. No mention was also made of the facilitation of learner reflection in mathematics problem-solving activities as prerequisite for metacognitive thinking. This finding is in concurrence with the literature reporting that teachers often lack awareness of their role in fostering metacognitive thinking with learners to examine their own learning and thinking of mathematics (Ader 2019, p. 621; Chapman 2015, p. 29; Güner & Erbay 2021, p. 716). Research by Yorulmaz, Uysal and Çokçaliskan (2021, p. 253) confirms a relationship between awareness of metacognition and beliefs about mathematical problem solving among pre-service teachers. A lack of teacher awareness of metacognition can thus also influence the way teachers value and implement PCL.

The participants demonstrated knowledge of a constructivist learner-centred teaching approach and the role of the teacher as facilitator. They did acknowledge, however, that in Grade 2, it is necessary to first teach the topic before expecting from them to solve problems on their own or in groups as explained by P1\_Frieda\_19 years teaching experience:

‘You must give them the tools... there is stuff that they cannot figure out for themselves that you have to teach them’.

At the end of this first focus group, the first author explained the principles of PCL in more detail before the planning for PCL lessons commenced. The teachers then collaboratively planned a PCL lesson for implementation in the first micro-cycle of Phase 2. They were reminded to accommodate the facilitation of metacognitive thinking through the reflective and collaborative solving of real-life problems. Strategies had to support learners’ reflective knowledge construction whereby the teacher took on a facilitating role in a learner-centred approach to problem solving.

## ■ Phase 2: Implementation of problem-centred learning in two micro-cycles

This phase consisted of two micro-cycles. In each cycle, teachers planned a lesson collaboratively and implemented the lesson in the classroom

followed by a reflective focus group discussion on the strengths and weaknesses of the PCL. Reflections on the first lesson informed the planning of the second to improve support for PCL. While the data analysis during this phase focused on participants' experience of the implemented and adapted PCL teaching strategies that were collaboratively planned during the micro-cycles, the implications of the findings for metacognitive thinking in mathematics learning by Grade 2 learners were at the core of the analysis process.

## □ **Micro-cycle 1: Lesson planning and implementation**

In this cycle, the participants collaboratively planned and reflectively implemented a PCL lesson based on the curriculum content prescribed for the specific time of the semester. The participants had to collaboratively choose a topic for the PCL lesson and measuring 'time' or 'money' was suggested as focus. During the planning session Susan showed an understanding that successful learning through PCL in Grade 2 is dependent on learners' prior knowledge and competence:

Time is difficult ... they have [prior knowledge] of money ... They use money every day, but no child owns a watch ... not one ... so time is a completely new concept for them.

Especially when aiming to support metacognition, it is important that the content links onto learners' prior knowledge and that learning tasks match the learners' developmental level. Grade 2 learners are still developing their understanding of mathematical concepts and relevant problem-solving strategies. To facilitate metacognitive thinking through PCL will therefore require a good knowledge of the learners' Zone of Proximal Development (ZPD) (Vygotsky 1978), because thinking may not be able to function at a metacognitive level before mastering the basic mathematical knowledge. The participants expressed concern regarding their learners' preparedness for PCL because of a lack of mathematical knowledge and their role in PCL. Frieda acknowledged that her Grade 2 learners are not used to collaborative problem solving and that problems should not be too difficult to solve independently in their groups when implementing PCL for the first time:

'You don't want to confront them with a problem that they cannot solve ... then you gain nothing. I mean ... then you only discourage the learners. So, I think we should rather start with easier problems and then move on to more challenging ones, until they have mastered the skill ... they are not used to this [problem-centred learning] approach.'

Collaborative learning is a core principle of PCL and working in groups is reported as beneficial to metacognitive learning. However, careful consideration is necessary when grouping learners to ensure meaningful learning by all learners in the group. Participants had to decide on the best

way to group the learners and a discussion concerning heterogenous or homogenous grouping followed. Being Elsa's first year in practice, she was still experimenting with different groupings:

'Elsa [S1R]: I am also trying to do group work. But I was first trying to mix the groups up ... strong learners and weak learners, and just the weak ones. And ... like ... both of them have benefits and both not ... but I am still working out on that .... just to see which one is better.'

The participants collaboratively decided to use homogenous ability grouping based on guidelines of the DBE (Du Plooy 2019). Informed by their knowledge of their learners' level and background, they agreed to focus on 'money' as topic from the Curriculum and Assessment Policy Statement (CAPS) for the two PCL lessons as a real-life problem in the two micro-cycles. The collaborative lesson plan entailed that the introduction focused on a revision of previous knowledge concerning the value of the different coins. As resources, they used large cardboard coins posted on the board, while teachers explained the value and focused learner's attention on their physical features. The planning of problem-centred collaborative learner tasks was directed at existing homogenous ability groups consisting of five to six learners per group. To accommodate the real-life principle of PCL, the teachers decided to set up a 'shop' using play money representing the South African coins as well as merchandise labelled with prices. Shopping lists were printed to guide the problem-solving activities. Each ability group received a different shopping list that accommodated their different problem-solving ability levels. Through role-play, the 'customers' needed to work out in their groups, the money they needed to pay for their shopping while the 'shopkeeper' had to work out each customer's change. The closure phase implemented in both lessons in the respective cycles required learners to complete a worksheet based on problems with money to assess their understanding.

After the collaborative planning, each participant implemented the lesson in their own classrooms. One teacher volunteered that her implementation of the PCL lesson can be video recorded. Participants were expected to continuously reflect in their journals on their experience of the collaborative planning, implementation, reflection and adaptation of the PCL lesson. In the focus groups after the implementation, the participants watched the recorded lesson together and collaboratively reflected on the success and what should be adapted. The lesson was then collaboratively revised for the implementation in the next micro-cycle.

The data collected in this phase pointed out that teachers acknowledge the value of PCL principles, but expected various factors that could hamper the implementation thereof. Suggestions were also made in their reflective journals for adjustments to improve and develop the PCL teaching strategies.

Most participants struggled to come to grips with the active learning in groups which was often experienced as disruptive and chaotic. In her journal, Susan reflected on the process that needs to be followed in the next cycle to structure the teaching–learning process better:

‘By firstly identifying the problem, then solving it practically, then giving a worksheet to assess it’.

Data collected during the lesson planning and implementation phase showed limited quotations making explicit mentioning of metacognitive thinking to support learners’ understanding of their own thinking and learning processes through PCL. However, informed by the literature and using a metacognitive lens, evidence of the role of reflective learning, learner-centred knowledge construction through the solving of real-world problems, and reference to the facilitating role of the teacher, were acknowledged as supportive of metacognitive thinking as demonstrated by the quotations collected through the reflections after micro-cycle 1 reported next.

### □ **Reflection after micro-cycle 1**

P1\_Frieda\_19 years teaching experience clearly brought into the action research process and her enthusiasm sometimes led to her dominating conversations with younger less experienced participants often withdrawing from the conversation. Focus group discussions therefore sometimes reflected P1\_Frieda’s 19 years teaching experience’s one-sided experience, which hindered the collaborative development of PCL teaching strategies and is seen as a gap in the study. As an experienced teacher, P1\_Frieda\_19 years teaching experience acknowledged the role of the teacher as a facilitator that enables reflective and self-directed knowledge construction:

‘The children have to find their things (answers) themselves’.

While acknowledging SDL, she also reported the need for direct teaching through initial demonstration to Grade 2 learners. P1\_Frieda\_19 years teaching experience explained how a learner discovered the value of money through the PCL task:

‘When I showed him for the first time: How much is this? Two rand! Take your two rand... and then the next one, then he clicked, he has to unpack the prices. So, yes, they definitely learned something.’

P1\_Frieda\_19 years teaching experience’s quotation indicates her knowledge of mathematics and of how learners construct mathematics understanding by finding the answers themselves, while the teacher, as facilitator, guides the learner to come to an understanding by relying on their metacognitive skills (Mulholland 2021, p. 9).

The important role of the teacher as facilitator in scaffolding problem solving within the learners' ZPD (Purichia 2015, p. 2) was also demonstrated by P2\_Elsa\_6 months teaching experience when she suggested that the initial problem may have been too challenging:

'And as they improve, one can make the problems more challenging, you see? One should first ensure they master the skill.'

When learners lack the basic mathematics knowledge it can hinder metacognition coming into its own. Frieda, who has 19 years of experience as a teacher and has worked with Grade 2 learners for eight years, emphasised the learners' lack of knowledge and skills regarding the money system:

'Some don't know how to write there: Two Rand, R1.50... they don't know how to use the one rand and the fifty cents... it takes practice to teach them that. About [writing] the 'R, the one, and then the comma and then the cents at the end... and then you still have to teach them the cents, say you have a 25c and a 75c ... when they are added they now move over to the Rand.'

P1\_Frieda\_19 years teaching experience is aware that the learners may not have had sufficient prior knowledge of money as a topic and that this could have had an influence on the realisation of PCL teaching principles such as metacognition:

'Maybe that was our problem, we could have chosen an easier one (topic).'

P1\_Frieda's 19 years teaching experience's statement indicates that she herself reflected on why the lesson did not come to its full potential. This reflection on inappropriate task choice echoes warnings reported in the literature concerning the identification of PCL tasks that will support metacognitive thinking (Güner & Erbay 2021, p. 717; Koskinen & Pitkäniemi 2022, p. 2; Scheibe et al. 2023, p. 1). The value of action research in alerting teachers to the consequences of their choices of learner tasks and the way a teaching approach supports knowledge construction is evident. The collaborative critical reflection on the implementation of their lesson, meaningfully supported and directed the development of the teachers' own views and knowledge of PCL strategies.

For the PCL activities, the learners were allowed to use their own methods to solve the problems and to represent their answers. Some learners drew circles, representing counters, to solve the problems as noted by the main researcher in her research journal: 'She told them they could represent their answers in their own way when solving the problem'.

The fact that learners could use their own methods to solve problems reflects a constructivist approach to mathematics teaching that supports

metacognitive thinking (Meher, Baral & Bhuyan 2021, p. 47). For optimal use of this opportunity to support metacognition, the teacher will however need to continue to facilitate metacognition in PCL by asking questions to support reflective learning to help learners 'arrive at the correct mathematical judgments' (Schoenfeld 2016, p. 29).

Barriers to support PCL as a learner-centred approach were mentioned by participants in their reflective journals; P2\_Elsa\_6 months teaching experience noted that the groups were too large to facilitate 'independent learning'. She reminded herself of the need to adjust in the following ways:

'Provide more support, improve differentiation, don't use worksheets.'

P3\_Susan\_3 years teaching experience was also written in her journal:

'Do not make activities too difficult for the learners; Make sure that the lesson is on the learners' level. [focus] on things that they are in contact with/involved in in their daily lives so that it can be easier for them to implement the lesson.'

After watching the video of the recorded lesson with her colleagues, P1\_Frieda\_19 years teaching experience confirmed P3\_Susan's\_3 years teaching experience's observations of a learner who unsuccessfully tried to solve the problem by drawing the coins:

'...because he made balls, and then he made numbers and then he made balls again, I think he got confused.'

The journal inscriptions and collaborative reflection in focus groups highlight the value of action research as an opportunity for teacher development, guiding them to reflect on the appropriateness of their strategies to support deep learning with understanding. Viewing the video also alerted them to possible barriers the learners may experience, which often go unnoticed.

The planned activities provided an opportunity for self-directed exploration of the solution. P1\_Frieda\_19 years teaching experience shared her observations when learners had to calculate their change when 'buying articles in the shop':

'They have now unpacked that money...R1.50; R1; R2; 50c and then put the Rands together and then saw: Wow! But these cents are left, those two make a Rand and these are still left. How much do I need to fill this up? That's my change!'

This observation strengthens the case for PCL as a formative assessment opportunity, whereby teachers have the opportunity to observe learners' representations of their thought processes. As the facilitator of metacognitive thinking in PCL, the teacher can then intervene with guiding questions on alternative strategies to solve the problem should it be clear that the learner needs support.

## □ **Micro-cycle 2: Lesson planning and implementation**

After collaborative reflection on the strengths and weaknesses of their PCL lesson implemented in the first cycle, the participants agreed on ways to revise teaching and learning strategies to be implemented in the second cycle. In the first micro-cycle, the teachers found it difficult to manage the collaborative learning in larger groups. Collaboration in the large groups was found to be ‘chaotic’ at times (Ma et al. 2021, p. 269), because the learners were not used to learning mathematics collaboratively. The excitement of working with real-life objects and learning through play also contributed to higher noise levels. To improve support for PCL they decided to rather let learners work in pairs than in groups. They believed that collaborating in pairs would ensure each learner grapples with the problem rather than relying on the group. Working in pairs would also give each learner the opportunity to communicate their thought processes and solutions that will provide an opportunity for input from the peer. Participants also believed that collaborating in pairs will provide the teachers better opportunities to assess and support metacognitive thinking with learners by asking guiding questions relevant to the specific learners’ demonstrated thought processes.

### □ ***Reflection after micro-cycle 2***

Collaborative learning as a principle of PCL potentially offers the teacher the opportunity to step back after the problem has been given to learners. Reflective revising of PCL teaching strategies entailed that learners from the same ability groups were paired to solve money problems. Each learner received a shopping list and the learners had to take turns to act as the shopper and shopkeeper. Problems required learners to, in turn, work out the total to be paid for goods bought and the change to be returned to the shopper by the shopkeeper. Play money was used and pictures of groceries replaced the real objects to be purchased.

P1\_Frieda\_19 years teaching experience, P2\_Elsa\_6 months teaching experience and P3\_Susan\_3 years teaching experience confirmed that pairing learners was more effective as a PCL strategy than larger groups. P2\_Elsa\_6 months teaching experience noted in her journal that she will work in pairs more in future. P3\_Susan\_3 years teaching experience agreed but added that she preferred ‘pairing a strong learner with a weaker learner so that the stronger one can help the weaker learner’.

However, not all participants were in agreement concerning this heterogenous grouping. P1\_Frieda\_19 years teaching experience commented:

'I don't like this at all. One never knows if the weaker learner is learning to think for himself. He then remains weak. I would rather pair two weaker learners and give them easier problems to figure out on their own. When you figure it out on your own the light goes on and next time, he will get it right.'

The dilemma of choosing between homogeneous or heterogeneous groupings has been argued in the literature (Hutchinson, Jones & Griffith 2021, p. 1584). While teachers differ in views on grouping strategies, P1\_Frieda\_19 years teaching experience made a valuable observation. Whichever grouping strategy is used, the main aim is to support each learner to learn with understanding. She referred her colleagues to evidence in the recorded lesson implementation, where one learner was clearly playing shopkeeper and customer when solving the problems on her peer's behalf, who could not solve the problem.

After the revised lesson, P3\_Susan\_3 years teaching experience reflected as follows on the value of the real-life focus of the problems:

'So I really think at the end they achieved their answers and come right it make so much sense to them... when they actually work with money, they understand and go back to it because they practically understand it better and then it makes more sense. But [they] say: 'Remember we played shop-shop, we bought it?' 'Yes! I remember!' I just feel it was really good ... the strategy.'

P1\_Frieda\_19 years teaching experience confirmed the benefits when learners solve real-life problems in PCL:

'When they are actively involved in the work, and you see ... that child now knows what he has to do there. Then you also notice your children's abilities.'

P1\_Frieda's\_19 years teaching experience's comment above emphasises the value of real-life problem solving with concrete resources in smaller groups (Ondog & Kilag 2023, p. 310). This provides the teacher with the opportunity to observe the learners' thought processes, understanding and skills while learners are actively involved in the solving of problems. Informed by their observations, teachers can provide timeous support towards the learning aims through posing guiding questions, rather than relying on the summative marking of worksheets in which learners often copy the answers from their peers.

Participating teachers acknowledged that there were several flaws in the way the PCL lessons were implemented and a follow-up macro-cycle would have helped to further develop strategies that are workable in their teaching contexts. Retrospection of data collected in the first two phases informed suggested strategies that could help to accommodate PCL in similar contexts. The researcher critically reflected on the implications of barriers that hamper PCL with a specific focus on metacognitive thinking, as crucial to mathematics learning with understanding.

### ■ Phase 3: Retrospective reflection on problem-centred learning teaching strategies after completion of problem-centred learning lessons

While the principles of PCL deductively influenced the analysis of the data, the aim of this chapter is to understand how factors emerging from the findings could influence metacognitive thinking as an outcome of PCL lessons. It was clear after the first lesson that teachers were not convinced that PCL would work in their specific contexts, which would also have implications for the way metacognitive thinking would be accommodated in their classes. Although they acknowledged the value of the principles of PCL, it seemed that teachers were mostly still relying on direct teaching approaches and were hesitant to explore strategies that would challenge classroom management. P1\_Frieda\_19 years teaching experience mentioned more than once that this is a 'new approach' for learners. P2\_Elsa\_6 months teaching experience also mentioned in her journal: 'It's going to be very new for the learners, some will be able to do it others not'.

Teachers were obviously not prepared for an approach where learners are actively involved in the collaborative solving of problems. P1\_Frieda\_19 years teaching experience described that in the implementation of the first lesson, she thought she would 'go crazy', having to be at different places at the same time. Challenges shared include a lack of discipline, PCL is time consuming and language diversity makes collaborative learning challenging. There was also a shared view that Grade 2 learners still require direct teaching of the mathematical concepts to ensure they have the necessary knowledge and skills to solve real-life problems, before a learner-centred approach such as PCL can be considered. These challenges were summarised by P1\_Frieda\_19 years teaching experience:

'... but, we will still have to guide those ones a lot. And they will struggle with the language in the first place and in the second place they will not know if it is a plus or a minus.'

Although teachers did not experience the first lesson as productive, P1\_Frieda\_19 years teaching experience experienced her implementation of the adapted PCL lesson in the 2nd micro-cycle after adaptations as successful:

'I thought it (lesson) was very relevant and the strategies worked well for me.'

P2\_Elsa\_6 months teaching experience also experienced this implementation as a more positive experience. However, she believed teachers are not yet proficient in the principles of PCL and that regular implementation could possibly strengthen these principles:

'So I think it can work. Only it takes much longer. But for me, I think it can work.'

P2\_Elsa\_6 months teaching experience's reference to more time required for PCL implies that teachers will have to plan well to accommodate this learner-centred approach.

## □ Implications of teacher experiences for metacognition through problem-centred learning in Grade 2

Although participants did not specifically focus on the role of metacognition in their reflections, the teachers' experiences, views, and attitudes will determine if and how they will implement PCL and the way metacognition is supported.

We argue that support for metacognition to enhance learning of mathematics with understanding requires teachers to employ a learner-centred, problem-centred approach to mathematics education. Motivated by the literature on the interrelated principles of metacognition, including real-life problems and collaborative learning in a classroom where the teacher facilitates the construction of knowledge in a learner-centred approach, will create an environment conducive for metacognitive thinking processes (Ridlon 2009, p. 193). Therefore, the confirmation of the way the other four principles are supported, also holds value for metacognitive thinking.

It was clear that both teachers and learners were not used to collaborative learning in small groups of five to six learners as implemented in the first lesson. However, the teachers found the homogenous pairing of learners more productive and supportive of reflective learning. Simon (1986, p. 40) supports this notion while Brame and Biel (2015, online) indicate that the ideal number of learners for meaningful problem solving can vary from two to five, depending on the learning purpose and type of problem.

Concerning the focus on real-life problems, mention was made of the way in which this context promotes learning and deeper understanding. P3\_Susan\_3 years teaching experience referred in her journal to the role of concrete and real-life teaching-learning materials in the way learners form understanding. She realised that young learners learn more effectively through play and that enjoyment plays an important role in their understanding:

'Learner enjoys doing practical work; they find it interesting and it's very meaningful. There are many methods to solve a problem in mathematics when doing it practically. This way the learner understands it better.'

P1\_Frieda\_19 years teaching experience agreed that using real-life concrete learning material added value to problem-solving activity. Her comment reflects support for metacognition as learners are in control of their own

learning process and can come to a deeper understanding by constructing their own understanding:

'It is more practical; Yes, that's what I feel, with this one (lesson) it was more practical, and they actually understood what they were doing, and it made more sense to them.'

P1\_Frieda's\_19 years teaching experience's reference to the value of PCL to develop SDL in a learner-centred approach was also supported by P2\_Elsa\_6 months teaching experience where she indicated in the questionnaire that 'PCL teaching strategies should develop self-directed' learning in learners. Metacognition is an important part of SDL. Thus, metacognition can also be supported by PCL if the teacher facilitates this skill. P2\_Elsa\_6 months teaching experience also referred to lifelong learning as an advantage of PCL related to metacognition and SDL.

Mention made to the way in which PCL accommodates the different learning styles of learners also reinforces the value of PCL. P1\_Frieda\_19 years teaching experience reminded her colleagues of the need for a learner-centred approach that accommodates diversity when aiming to support the development of metacognition in learners:

'[... 7]he right brain is actually looking for, those things to play with, the objects and colours and such... you actually involve both. Because they learn in different ways, left brain and right brain learn in different ways. You don't think so, but they do.'

Mention was also made to reflection as outcome of PCL that holds value for metacognitive thinking. Marie responded on the questionnaire that she experienced PCL as meaningful because 'learners' skills improved, and they learned to take responsibility for their own learning and solutions. Problem-centred learning makes them thinkers, and this will help them throughout their lives.

P1\_Frieda\_19 years teaching experience also referred to the important role of reflection in metacognition and expressed her satisfaction with the learner's reflection at the end of the second lesson. She highlighted that SDL was observed when learners were led to reflect on their own understanding of what they have learned:

'So I think the reflection said to a lot of kids "aaahh! It was like that!" I think the reflection at the end is a must. It is definitely a must for those I couldn't get to, to also get on the bandwagon.' [C23]

P1\_Frieda\_19 years teaching experience noticed that, although there is a place for worksheets in mathematics, they can also hinder reflective learning and that more room should be made for problems that are solved practically:

'And the worksheet...Sometimes they tend or try to complete the worksheet, without working on the problem.' [C2R]

The participants’ experience of the value of learner reflection on what they have learned as a principle of PCL is also confirmed in the literature (Krause & Starka 2010, p. 259). Reflection at the end of a lesson can play an important role in giving learners the opportunity to meaningfully connect new concepts with previous knowledge. It also gives teachers the opportunity to determine which learners have not yet mastered the new concept. However, to develop metacognition with young learners that will enable them ‘to be aware of what they know and do not know by engaging in reflective processes, and to take action to address flaws or gaps in what they know by employing self-regulation’ (O’Hara, Pritchard & Pitta 2019, p. 2), will require teachers to continuously support reflective learning and not only at the end of a lesson.

## ■ Summary of teachers’ experiences after the three cycles

Table 7.1 presents guidelines that emerged through the analysis of data generated from the participants’ experiences of a PCL approach to mathematics education.

**TABLE 7.1:** Guidelines for implementing problem-centred learning in mathematics education.

Theme	Suggested guidelines
Social constructivist approach	<p>Connect with learners’ prior knowledge.</p> <p>Problems must be stated simply and clearly to make sure learners understand what is expected of them.</p> <p>Direct activities towards the learners’ real-life experience to foster meaningful problem solving.</p> <p>Learners should be gradually exposed to more challenging problems.</p> <p>Provide opportunities for learners to solve problems using concrete learning materials.</p> <p>Learners co-construct knowledge by solving problems in pairs (Social Constructivism).</p>
Collaborative teaching strategies to support social constructivist learning	<p>Pairing learner in homogeneous groups promotes meaningful learning and improves classroom dynamics.</p> <p>Using larger PCL groups complicates classroom management and the monitoring of learning.</p>
Accommodation of learner reflection as part of the PCL lesson	<p>Learners must be given sufficient time for reflection at the end of the lesson.</p> <p>Learners should share their problem-solving methods and solutions.</p> <p>Learners should verbally explain their solutions to the large group, expressing their understanding.</p>
The role of the teacher as facilitator	<p>The teacher’s role as facilitator empowers learners to solve problems independently in groups.</p> <p>The teacher provides support by guiding learners with questions when needed.</p> <p>Facilitation is key for creating opportunities for meaningful collaborative learning through learner knowledge construction and guided problem-solving reflection.</p>

Source: Author’s own work.

Key: PCL, problem-centred learning.

The lack of explicit reference to experiences of strategies that support metacognition could possibly be an indication that the facilitation of higher-order thinking does not really materialise in this teaching context and/or with learners at this developmental level. However, the relationship between social constructivism, reflection, collaborative problem solving and metacognition implies that the support of one principle will necessarily also have an influence on the other principles. Therefore, it is possible that these proposed strategies do also support metacognition. Further investigations will possibly be able to indicate whether more guidance to teachers regarding strategies for metacognition will have an influence on their experience of metacognition as a principle in PCL.

## ■ Conclusion

Grade 2 learners are still at the level where they develop the necessary strategies to solve problems independently, which means that they may not yet function independently on a metacognitive level. However, this does not mean that they cannot be supported to develop metacognitive thinking skills (Chen et al. 2022, p. 5). Mathematical understanding is promoted if learners communicate their knowledge and understanding with others (Botes & Mji 2010, p. 123). In addition, learner reflection is supported by the socio-constructivist approach to teaching (Krause & Starka 2010, p. 260). The participants recognise reflection as an important strategy when the pairs solve the mathematics problems together and when the learners share their solutions with their classmates at the end of the PCL lesson. Communication is an important medium for understanding mathematics (Botes & Mji 2010, p. 125). Biccard and Wessels (2011, online) echo this view and are of the opinion that teachers should ask learners more questions that challenge learners to reflect on their knowledge. It also confirms the role of the teacher as facilitator as considered important by the participating teachers.

Although the study focused on the development of teaching strategies for PCL of mathematics in Grade 2, the greatest value of the study lies in the action research process. Through the collaborative planning and implementation of teaching strategies, the observation and critical reflection on their significance and the joint planning of ways to overcome obstacles, a community of teachers was established. In a country where we have to throw everything into the fight to ensure quality education for our children, this type of community of teachers will be able to contribute to building good practice and learning from and with each other.



# Grade 7 mathematics learners' metacognitive thinking in problem-based tasks<sup>5</sup>

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## ■ Abstract

This chapter deals with Namibian Grade 7 learners' application of metacognitive thinking while working on mathematics problem-based tasks. Metacognition involves intentional and purposeful thinking about one's own cognitive processes and plays a crucial role in mathematical problem-solving. A qualitative research methodology was followed, and one cohort of 36 Grade 7 learners participated. Class activities were structured according to group work where six learners worked together. The intervention comprised two problem-based mathematics tasks, the completion of mathematics worksheets and reflective sheets, as well as individual semi-structured interviews. A method for thematic data analysis was developed using MS Word and MS Excel. Four themes emerged from the inductive analysis. It was evident from the qualitative findings that metacognitive thinking is crucial in the solving of mathematics problems, and as a result, the learners developed essential skills that will be valuable for the future. The implementation of problem-based tasks in Grade 7 not only supported the learning of mathematics subject content, but findings also indicated it as an effective strategy to assist learners in developing critical skills when dealing with real-world problems. In addition, the participating learners developed certain self-directed learning (SDL) abilities. There was evidence of self-directed characteristics, such as setting learning goals, determining learning needs, persistence, self-reflection on experiences and responsibility.

## ■ Introduction

This chapter focuses on the significance of metacognitive thinking in real-world mathematics tasks. Mathematical thinking requires a repertoire of abilities to deal with real-world problems (Boelt, Kolmos & Holgaard 2022, p. 1399; Topsakal, Yalçın & Çakır 2022, p. 136). Part of this is the ability of learners to collaborate and to engage in complementing their knowledge and skills in problem-based contexts (Hernández de Menéndez et al. 2019, p. 909). Problem-based activities allow for open-ended problems where the solutions are not obvious, and collaboration is required to solve problems with peers (Boelt et al. 2022, p. 1400). As learning in such contexts is challenging, the use of metacognitive thinking is crucial. Metacognition refers to the self-knowledge, awareness and regulation of an individual's cognitive processes (Flavell 1979, pp. 906–911). Several scholars consider metacognition as critical for succeeding in mathematics (Gómez-Chacón et al. 2023, no page; Özkubat & Özmen 2021, p. 443). Mathematical thinking is therefore not only supported by cognitive processes but also requires tandem abilities of reflective thinking and effective control of such cognitive processes.

Unfortunately, younger learners are not necessarily exposed to real-world problems and managing their own thought processes. For example, such learners tend not to read questions thoroughly and meaningfully, and they do not necessarily use higher-order thinking skills to solve problems (Mulwa 2015, p. 27). Furthermore, several learners struggle with logical reasoning and face difficulties in connecting mathematical concepts, which are essential for understanding mathematics (Ndiung & Nendi 2018, p. 1). Another obstacle is a negative attitude towards school mathematics. Learners who view mathematics as difficult, challenging and only meant for the intellectuals, tend to lose interest and the motivation to learn. This may result in an inability to solve open-ended problems and poor performance in the subject (Gómez-Chacón et al. 2023, no page). Learners do not necessarily seek guidance or assistance when they are unable to solve such problems; consequently, they do not take responsibility for their own learning (Kleopas 2020, no page; Massonnie et al. 2022, p. 58).

Self-directed learners can monitor and regulate their thinking and learning more effectively than learners who are not self-directed (Karatas & Arpacı 2021, p. 13). It is particularly important to equip mathematics learners with essential knowledge and several thinking skills to solve more challenging problems. Consequently, this chapter aims to report on Grade 7 mathematics learners' metacognitive thinking in problem-based tasks. These questions directed the research:

1. How do problem-based mathematics tasks contribute to the development of learners' metacognitive thinking?
2. What is the nature of Grade 7 learners' metacognitive thinking when solving mathematics problems?
3. How does the use of metacognitive thinking foster the development of self-directed learning (SDL) skills?

## ■ Aspects related to the learning of mathematics

Social constructivism, developed by Lev Vygotsky, emphasises the nature of learning where knowledge is constructed in formal social settings (Vygotsky 1978, p. 7). Social interaction is essential, requires active engagement and aims to contribute to meaningful learning experiences and one's own understanding of the world (Creswell 2018, no page). Knowledge is therefore constructed when learners explore, discover and actively participate in challenging mathematical problems. The zone of proximal development (ZPD) is relevant to problem-based contexts. In this regard, Harland (2003, p. 263) highlighted how Vygotsky's theory regarding ZPD informs educational praxis using problem-based learning (PBL) in a

specific course by focusing on authentic class activities. Sembiring and Amaliah (2017, p. 72) studied middle school learners who were experiencing difficulties with mathematics and problem-solving. They emphasise Vygotsky's views regarding learners' interaction with peers to address challenging problems.

In this chapter, the authors focus on the teaching and learning of mathematics, PBL tasks, metacognitive thinking in mathematics and the importance of SDL.

## ■ Teaching and learning of mathematics

Mathematics refers to the discipline of abstract science concerning numbers, measures, quantities, shapes, space, abstractions and associated concepts (Yadav 2017, p. 34). Mathematics therefore fosters an understanding of subject-specific principles, offers opportunities to analyse problems logically and provides the mathematical foundation needed for further study (National Institute for Educational Development [NIED] 2014a, no page). Teaching mathematics is about inspiring learners to work independently and nurturing them to develop as problem solvers and critical thinkers (National Council for Mathematics Teachers [NCTM] 2016b, no page). Furthermore, teachers should assist learners in developing the ability to solve open-ended and real-world mathematics problems (Altay, Yalva & Yeltekin 2017, p. 158; Menanti, Sinaga & Hasratuddin 2018, p. 331). Unfortunately, learners do not necessarily understand mathematics concepts, and they experience challenges in solving ill-structured and real-world problems (Jourdain & Sharma 2016, p. 44).

Learning mathematics from an early age assists learners to develop qualities, such as perseverance and persistence, which may help them to succeed. Madosi, Spangenberg and Ramdhany (2020, p. 181) and Seah et al. (2016, p. 14) emphasise that determination and diligence in mathematics can impact learners' reasoning, intellectual capacity and motivation to learn the subject. Learners who are supported can appreciate what they learn and are encouraged to persist in solving mathematics problems (Madosi et al. 2020, p. 181). Moreover, active strategies, such as PBL, have proven to promote effective learning, as it should be learner-centred and actively engage learners in class activities (Hernández de Menéndez et al. 2019, p. 909). Sembiring and Amaliah (2017, p. 72) emphasise the importance of understanding mathematics, for example, the meaning of formulas and their application in real-world contexts. They elaborate and refer to the ability of applying reasoning and problem-solving, drawing conclusions and knowing how to apply mathematics in challenging contexts.

## ■ Problem-based learning tasks

Teaching and learning go hand in hand, and suitable teaching–learning strategies should be used. Problem-based learning is ‘an instructional learner-centred approach that empowers learners to conduct research, integrate theory and practice and apply knowledge and skills to develop a viable solution to a defined problem’ (Savery 2015, p. 7). Yew and Goh (2016, p. 76) agree that PBL as a teaching–learning strategy enables learners to learn from each other, while actively engaging with meaningful problems. In PBL, carefully designed, ill-structured problems are presented to collaborative groups who are tasked with discussing these issues and proposing tentative solutions for the problem at hand (Savery 2015, p. 8). In PBL, the teacher and the learner have different roles. The teacher encourages enquiry and autonomous learning and facilitates problem-solving and knowledge creation, while learners are expected to share responsibility, apply various thinking skills and solve open-ended problems (Havenga 2015, pp. 138–140).

Collaboration in small groups is an essential feature of PBL. Learning in small groups encourages peer learning, with group members supporting one another (Rajabzadeh, Mehrtash and Srinivasan 2022, p. 454). In addition, Rajabzadeh et al. (2022, p. 454) note that learners ought to develop several abilities, including knowledge enhancement, critical thinking, social engagement and course satisfaction. Learners may, however, also experience challenges while working together in PBL settings, for example, poor communication and pressure to conform to group decisions (Ferdous & Karim 2019, p. 342).

Problem-based tasks allow learners to develop conceptual understanding in solving an open-ended problem or addressing a specific challenge (Aziza 2017, pp. 2–3). Such tasks could foster learners’ curiosity to conduct investigations and inquiry, and develop their ability to think critically (Herlanti et al. 2017, pp. 179–180; Siagan, Saragih & Sinaga 2019, p. 333). When planning PBL tasks, teachers need to identify inspiring problems and formulate suitable questions with the aim of guiding the class activities. Simultaneously, learners should be motivated to take risks when participating in these activities (Suwartono & Oktavia 2019, p. 47). Furthermore, educators must anticipate potential misconceptions to effectively support learners throughout the problem-solving journey (Sumitra, Nurunnisa & Lestari 2020, p. 90). As a result, teachers must anticipate difficulties learners might encounter and should be able to assist them towards finding a solution. Their planning should include activities (PBL steps), such as clarifying concepts, formulating the problem, brainstorming, structuring information, formulating learning objectives, searching for resources, reflecting on learning and evaluating the outcome.

Furthermore, learners must understand that the group shares the responsibility for completing the task and the group's success depends on the participation and contribution of every member (Savery 2015, p. 8). Consequently, guidance regarding dynamic group work is crucial, and Mohd-Yusof et al. (2011, p. 13) highlight the importance of cooperative group work in PBL contexts.

## ■ Metacognitive thinking in mathematics

Metacognition refers to a person's ability to monitor and regulate his or her own thought processes (Flavell 1979, pp. 909-911). Flavell distinguishes between metacognitive knowledge (knowledge about strategies, personal knowledge and knowledge about the task) and metacognitive regulation (planning, monitoring, evaluation and reflection) as essential mental processes to support cognitive inquiry (Flavell 1979, p. 910) (see Chapter 1).

Several scholars emphasise the importance of metacognitive thinking in mathematics and problem-solving. Gómez-Chacón et al. (2023, no page) highlight the ability to control the cognitive mind to understand mathematics concepts and solve problems. Erbay and Güner (2021, p. 715) agree and point out that learners must demonstrate metacognitive thinking in terms of planning, monitoring and evaluation, and adjust their own learning behaviours to deal with challenging tasks more effectively. Consequently, learners must be able to recognise their own cognitive abilities, activate prior knowledge, direct their own thinking, evaluate their performance, understand what caused their successes or failures, compare several answers and implement appropriate strategies (Alzahrani 2017, p. 79; Ramadhanti & Yanda 2021, p. 193). For example, learners involved in critical discourse - sharing ideas with the mathematics teacher and their peers - use a valuable metacognitive strategy to complement problem-solving. Winne (2016, p. 559) emphasises that mathematics teachers need to guide learners purposefully for active reflection throughout the learning process. Learners are expected to provide feedback in a constructive way, revise their work and determine their strengths and weaknesses in solving mathematics problems (Winne 2016, p. 562).

Individuals with high metacognitive awareness have knowledge of what they know, and they are aware of some gaps in their knowledge (Dağal & Bayındır 2016, p. 2533). This implies that learners need to manage their learning process, conduct research and draw conclusions (Mohamad, Halim & Abd Talib 2020, p. 227). Khodaei et al. (2022, p. 1) further suggest that actively fostering metacognitive abilities, such as self-awareness, could improve learner self-confidence, motivation and SDL. Metacognitive thinking affects learners' motivation to learn, as it directly influences

attribution and self-efficacy, and is valuable because it assists learners in becoming more self-directed (Fitrawati 2014, p. 159). To achieve success, it is imperative that mathematics learners become responsible for their own learning. Teachers must communicate and model metacognitive strategies to learners and provide them with ample opportunities to employ such strategies. Examples of metacognitive strategies include asking questions, choosing an appropriate problem-solving approach, engaging in collaboration and cooperation, writing a journal and reflecting on one's thinking (Astriani et al. 2020, p. 4). In addition, teachers ought to expose learners to appropriate assessment strategies, including self-assessment (Rickey, DeLuca & Beach 2023, no page).

## ■ The importance of self-directed learning

Self-directed learning is a crucial process to assist in learning (Knowles 1975, p. 18). Self-directed learning has the features (see Chapter 1) outlined below.

- It involves a continuous and dynamic process of learning (persistence in learning).
- It requires responsibility and accountability (taking initiative in the learning process, identifying learning needs and formulating specific goals).
- It refers to selecting and evaluating relevant sources to enhance the learning process.
- It assists the learner in deciding on appropriate learning strategies.
- It helps the learner evaluate whether the aims have been achieved.

According to Olivier and Wentworth (2021, p. 35), SDL involves a learner's ability to manage his or her learning journey by making certain decisions about learning and taking responsibility with the aim of developing as a lifelong learner. Self-directed learners are driven by internal motivation, such as the desire to succeed, the satisfaction derived from achievements and the necessity of obtaining specific knowledge (Hofmeyer 2016, p. 118). Moreover, self-directed learners can evaluate their learning needs by determining the gap between existing knowledge and new information. It involves effective planning, evaluation of resources to achieve specific objectives and prioritisation of essential tasks (Karatas & Arpacı 2021, p. 13). Learners who are self-directed can learn independently and are able to evaluate their own success critically (Maphalala, Mkhasibe & Mncube 2021, p. 237). Kim, Belland and Axelrod (2019, no page) emphasise learner autonomy and state that tasks should involve searching for relevant information, using various resources, and through discussions within small groups to evaluate the usefulness of their gathered information. These essential abilities are also required to assist in mathematics learning.

The teacher is responsible for planning class activities and scaffolding for active learning with the aim of promoting higher-order thinking (Ali 2019, p. 76). Moreover, when learners are exposed to challenging tasks, it is essential to provide a learning context and apply a strategy, such as PBL, to promote group work, reflection and reflective thinking (Savery 2015, pp. 7–9).

## ■ Research methodology

A generic qualitative research design was employed in this study (Kahlke 2014, p. 36). A qualitative methodology explores individuals' views and perspectives regarding certain real-life experiences (Creswell 2018, no page).

Qualitative researchers therefore endeavour to gather rich data in order to understand participants' experiences and social reality in the context of the study. A qualitative research design was suitable for this study as it explored contexts where Grade 7 learners collaborated in groups on open-ended mathematics problems. This research therefore focused on the views of individual learners and groups, their understanding of real-world mathematics problems and constructed meaning from their experiences, as indicated in the learners' reflective sheets and the semi-structured interviews.

## ■ Participants

In total, 36 Grade 7 mathematics learners in Namibia participated in this study. They were between 13 and 14 years old. Grade 7 learners were conveniently chosen, as the researcher (first author) was their mathematics teacher. The teacher randomly assigned learners to six groups of six members each using a random number generator online. Initially, the teacher introduced learners to PBL and group work. Although Grade 7 learners were not explicitly introduced to the theory regarding metacognition, they were requested to reflect critically on their thinking.

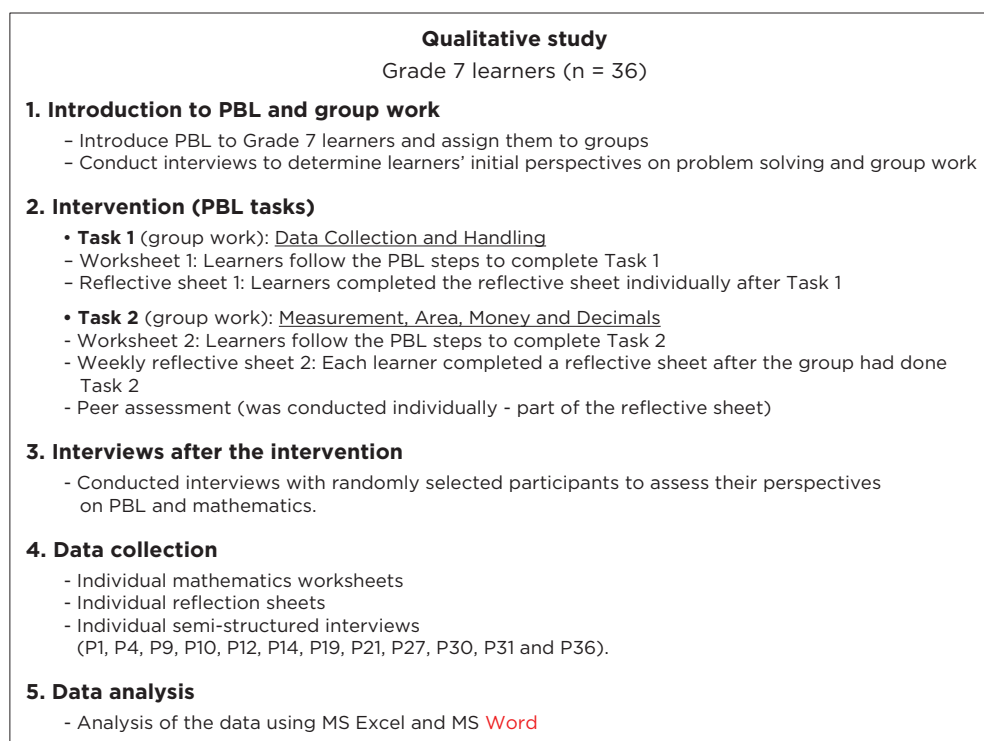
## ■ Ethical considerations

Ethical clearance was granted by the NWU-EMELTEN-REC Ethical Scientific Committee, Ethics application no: NWU-0068-19-A2. Written permission was obtained from the Namibian Department of Education (NED) to conduct the research at the school. Furthermore, the school principal and the School Governing Body (SGB) provided written permission. A mathematics teacher at the school, an independent person, assisted the

first author to obtain informed consent from the parents (or guardians) and informed assent from the participating learners. Confidentiality was assured by assigning codes to the participants (P1–P36). Printed copies of data were kept safe and electronic documents were password-protected on a computer. Pseudonyms were used when referring to individual Grade 7 learners.

## ■ Data collection

Data collection comprised mathematics worksheets (group work) and individual reflective sheets (see Figure 8.1). Twelve participants were randomly selected for individual task-based semi-structured interviews regarding their PBL experiences. An overview of PBL tasks is outlined in Figure 8.1, and this is followed by a detailed description of the problem-based tasks or scenarios.



Source: First author's own work.  
Key: PBL, problem-based learning.

**FIGURE 8.1:** Overview of the intervention and empirical research.

## ■ Problem-based learning tasks and class activities

Certain class activities pertaining to the PBL tasks are outlined.

### ■ Task 1: Data collection and handling

Problem-based learning problem scenario: the owner of the tuck shop sells certain drinks that learners prefer. He decided to approach you to assist in investigating their preferences. Apply the PBL steps that were initially introduced.

- Develop your own questionnaire to explore learners' preferences and collect data.
- Gather the data over a period of 4 days.
- Populate tables and present them as several types of graphs (two members had to compile a specific graph, for example, bar chart, pie chart and a pictogram).
- Compile a report and present the findings using flip charts, a poster and the chalkboard.

### ■ Task 2: Measurement, area, money and decimals

Problem-based learning problem scenario: The SGB plans to renovate several classrooms; however, their budget is limited. They intend to paint the walls, and either tile the floors or lay carpets. Your task is to assist and advise the principal on the most cost-effective renovation option.

- Measure the size of the room to determine the floor area.
- Calculate the number of tiles required to cover the floor.
- Determine the size of the carpet needed for the floor.
- Compare the cost of tiling versus carpeting.
- Calculate the amount and cost of the paint needed for the walls.
- Present your findings as a group presentation using flip charts, a poster and the chalkboard.

### ■ Data analysis

Because of technical challenges with computer-assisted qualitative data analysis software (CAQDAS), the second author developed a method for thematic data analysis using both MS Word and MS Excel. Initially, the track changes function in MS Word was utilised to analyse and code the data (see Figure 8.2). Table 8.1 illustrates a completed worksheet and the method the researcher used to code Participant (P) 4's reflective sheet. The steps were:

P4

**Reflective sheet task 1 (Before intervention)**

1. Explain in your own words what the mathematics task this week (entails) involves.
  - > Collection, analysis and presentation of data.
2. Discuss what problems you have experienced when you do the math task on your own.
  - > I did not know what to do.
3. Discuss the problems you experience when working on the math task with your peers (fellow learners) this week.
  - > Some people were laughing at others.
4. Give feedback regarding the support among your group members when addressing/solving the math task this week.
  - > Only some people worked.
5. Give feedback regarding your group's interaction (involvement) and communication when working on the math task this week.
  - > Some people worked with their friends only.
6. Give feedback whether your group has achieved their aims to solve the mathematics problem this week.
  - > Yes.
7. Explain how your group has addressed/solved the problems or challenges you experienced.
  - > We tell them to work.
8. Reflect on the pace (rate) of your group's progress to address the math task this week.
  - > It was ok.
9. Specify which information you searched (looked) for. List all the resources (where you have taken the information from) that you have used.
  - > Calculate angles and check the meaning of words. I used Oxford dictionary, Let's do maths grade 7, Incontext grade 7 and  $y=mx+c$  grade 8-10.
10. Give yourself and your group a mark regarding your effort (how you tried) to be responsible in addressing the math task this week.
 

PLEASE BE HONEST (0 - made no contribution, 10: provided an outstanding contribution and EXPLAIN WHY YOU ASSIGNED THIS MARK TO EACH MEMBER

  - > Member: 1-1 = 9 marks did a lot.
  - > Member: 1-2 = 9 marks also did a lot.
  - > Member: 1-3 = 4 marks was just laughing at people.
  - > Member: 1-4 = 9 marks I did a lot.
  - > Member: 1-5 = 5 marks was sick.
  - > Member: 1-6 = 9 marks did but not like us.

**Commented [s1]:** W1: mt: involves: collection, analysis and presentation of data.

**Commented [s2]:** W1: mt: own: do not know what to do

**Commented [s3]:** W1: mt: peer: some people laugh at other.

**Commented [s4]:** W1: mt: support: only some supported.

**Commented [s5]:** W1: mt: interaction: some worked with friends only.

**Commented [s6]:** W1: mt: achieved aims: yes.

**Commented [s7]:** W1: mt: how solved: tell them to work

**Commented [s8]:** W1: mt: progress: it was ok.

**Commented [s9]:** W1: mt: resources: calculate angles and meaning of words. Dictionary and Grd 7-10 text books.

**Commented [s10]:** W1: mt: contribution: 1(9), 2(9), 3(4), 4(9), 5(5), 6(9)

Source: First author's own work.

**FIGURE 8.2:** Analysis of P4's data in MS Word using track changes.

- Highlight and select specific words, sentences or sections that hold meaning in the participant's data using track changes in MS Word.
- Select all codes (comments) in all the track change balloons (Ctrl+Shift+End).
- Copy all the codes from the balloons and paste them into a new MS Word file within a table.

Specific categories emerged from the research, and they were colour-coded, combined and refined to represent a particular theme. The final results are presented in Table 8.1, which details the data collected from Participant 4.

These categories emerged from the analysis: Challenges, Progress in activity, Positive experiences, Resources, Communication, Contribution, Group collaboration, Self-directed learning, Mathematics tasks and Other.

**TABLE 8.1:** Responses from P4 before and after the intervention.

	Before the intervention	After the intervention
P4*	W1: mt: involves: collection, analysis and presentation of data.	W2: mt: involves: measure, area, money and fractions.
	W1: mt: own: <b>do not know what to do</b>	W2: mt: own: <b>do not understand task.</b>
	W1: mt: peer: some people laugh at other.	W2: mt: peer: <b>time was not enough.</b>
	W1: mt: support: <b>only some supported.</b>	W2: mt: support: <b>worked together and shared ideas.</b>
	W1: mt: interaction: <b>some worked with friends only.</b>	W2: mt: interaction: <b>we communicated.</b>
	W1: mt: achieved aims: yes.	W2: mt: achieved: <b>yes, we achieved.</b>
	W1: mt: how solved: <b>tell them to work</b>	W2: mt: how solved: <b>met when no teacher in class.</b>
	W1: mt: progress: <b>it was ok.</b>	W2: mt: progress: <b>we were fast.</b>
	W1: mt: resources: calculate angles and meaning of words. <b>Dictionary and G 7-10 text books.</b>	W2: mt: resources: find meaning of words, divide carpet. <b>Dictionary and grd 7-10 textbooks.</b>
	W1: mt: contribution: <b>1(9), 2(9), 3(4), 4(9), 5(5),6(9)</b>	W2: mt: contribution: <b>each 10/10.</b>
	I1: challenges: <b>finding answer to question I do not understand</b>	I2: challenges: <b>do not use calculator, big numbers, time not enough.</b>
	I1: solve others: yes, they can tell the answer.	I2: solve others: I am not always right, others help.
	I1: Determine needs: <b>yes, my needs to pass Mathematics.</b>	I2: determine needs: <b>yes, difference what I know and what I am learning.</b>
	I1: goals: yes, <b>my goals to pass Mathematics.</b>	I2: goals: yes I know to find goals.
	I1: learn responsible: yes, I study hard.	I2: learn responsible: <b>yes answer previous question papers and textbooks, do homework no one tell me to do.</b>
	I1: curious: yes, if I fail I make correction.	I2: curious: yes, problems tough but I try. [persistence]
	I1: comparing: yes, <b>best answer help get marks.</b>	I2: compare: yes if many ways I select best answer.
	I1: additional resources: yes, assisted by <b>friends and teachers.</b>	I2: additional resources: yes <b>textbooks.</b>
	I1: evaluate: <b>yes, see if answer correct.</b>	I2: evaluate: no <b>others check my answer</b>

Source: First author's own work.

Codes: W1 = Worksheet 1 (before intervention); W2 = Worksheet 2 (after the intervention); mt = mathematics task; I1 = Interview 1 (before the intervention); and I2 = Interview 2 (after the intervention)

## ■ Findings

Both concept-driven coding (from literature) and data-driven coding (from empirical research) (Gibbs 2010, p. 44) were used. These themes emerged from the analysis:

- Theme 1: Participants' mathematical knowledge and skills
- Theme 2: Collaboration in PBL tasks
- Theme 3: Nature of metacognitive thinking
- Theme 4: Advancement of SDL skills.

Regarding *Theme 1*, Participants' mathematical knowledge and skills, learners referred to some personal challenges and problem-solving strategies they used to overcome these challenges. For example, participants had difficulty in understanding the assignment and the real-world problem: 'Language is a problem; in most cases I do not understand the problem. I do not know what is being asked' (P14, gender undisclosed, 2022); 'To make a questionnaire was challenging ... I do not know what to do' (P5, gender undisclosed, 2022). They also experienced problems executing some mathematics tasks: 'It was not easy to measure and calculate [the] number of tiles and carpets' (P9, gender undisclosed, 2022); 'I forgot the formulae for calculating the area of a square and rectangle' (P36, gender undisclosed, 2022); 'I have a problem of dealing with big numbers in a calculation because we do not use a calculator and the time is not always enough' (P4, gender undisclosed, 2022).

Grade 7 learners also struggled to compare answers and decide on the best solution: 'Another challenge is getting different answers to the same question, it leaves me in a dilemma, not knowing which answer I should take' (P14, gender undisclosed, 2022). Another learner mentioned: 'I struggle to solve [a] complex problem requiring critical thinking in a short time' (P27, gender undisclosed, 2022).

To address certain mathematics issues, learners employed the following strategies: 'I looked for the meaning of words in the dictionary and textbooks' (P23, gender undisclosed, 2022); 'We exchanged ideas and supported one another' (P7, gender undisclosed, 2022); 'I searched for information about writing the number of learners as degrees (angles) to draw the pie chart' (P7, gender undisclosed, 2022); 'I searched how to calculate the area of combined shapes' (P27, gender undisclosed, 2022); 'We found out the number of 2-liter drums [needed to] paint the wall'. (P6, gender undisclosed, 2022).

*Theme 2* explored collaboration in PBL tasks. This theme outlines how Grade 7 learners collaborated on real-world mathematics problems. It highlights group attitudes, communication and participation among learners. Initially accustomed to working individually on mathematics tasks, learners held various beliefs about group collaboration: 'I enjoy group work because group work is easier and fast[er] due to many ideas' (P27, gender undisclosed, 2022); 'Some group members help[ed] to go [and] ask other groups the type of drinks they prefer' (P27, gender undisclosed, 2022). However, some challenges involved the following: 'Some group members were just quiet doing their own things instead of helping in solving the task' (P25, gender undisclosed, 2022); 'I don't like group work because all group members get marks, even those who did not do anything' (P32, gender undisclosed, 2022). Others considered group work as a waste of time:

'Group member[s] waste time and some people do not like other people's ideas' (P24, gender undisclosed, 2022).

Learners also emphasised the importance of communication and collaboration: 'We supported each other, our group exchanged ideas and thoughts to solve the task [...] Each member deserve[s] 10 out of 10' (P7, gender undisclosed, 2022); 'I learn from others and feel safe from making [a] mistake as they help me' (P14, gender undisclosed, 2022);

'I prefer working with other members because they might have better understanding, and share responsibilities. One member presented while the rest of the members were answering the questions posed by other groups.' (P27, gender undisclosed, 2022)

This highlights the different roles and responsibilities that individual members had.

The nature of metacognitive thinking is outlined in *Theme 3*. Metacognitive thinking and awareness of learning provided opportunities for learners to enhance ownership and control over their learning by using strategies such as planning, monitoring, evaluation and reflection. Participants highlighted the importance of planning mathematics tasks: 'I ask myself what I need to solve the problem' (P31, gender undisclosed, date 2022); 'I establish high expectation[s] and clear goal[s], work hard to achieve' (P10, gender undisclosed, 2022); 'I looked for graph-related information' (P13, gender undisclosed, 2022).

Learners who established goals organised their time and monitored their progress performed better than those who did not possess such skills. 'I take something from Grade 8 and see if I can solve it, if not then I ask for assistance' (P10, gender undisclosed, 2022); 'If I am wrong, I make correction[s]' (P21, gender undisclosed, 2022); 'When I am done, I re-read the question and check if [I] answered what was asked' (P14, gender undisclosed, 2022). Consequently, it was essential that learners evaluated their answers: 'double-check if [it] is correct' (P27, gender undisclosed, 2022); 'If I use different ways and did not get the same answers, I compare them and select carefully' (P24, gender undisclosed, 2022); 'I evaluate my answer to see if I am correct' (P7, gender undisclosed, 2022).

Reflection on learning experiences was crucial to identify issues in Grade 7 learners' mathematical reasoning. It involves thoughtful problem-solving and critical thinking to address real-world mathematics problems. Some feedback were the following: 'I feel bad when I do not understand' (P11, gender undisclosed, 2022); 'I make corrections on my own' (P27, gender undisclosed, 2022); 'When I get different answers to the same question, I take the best thoughtfully' (P36, gender undisclosed, 2022); 'We measured the length of the classroom and calculated the number of tiles and carpets

needed; it was not easy' (P9, gender undisclosed, 2022); 'Our mission is accomplished, we solved the problem' (P36, gender undisclosed, 2022); 'I enjoy challenging problems very much; they help me to learn new things' (P24, gender undisclosed, 2022).

In terms of *Theme 4: Advancement of SDL skills*, Grade 7 learners referred to several skills they developed.

- They set their own learning goals: 'I establish high expectation[s] and clear goal[s], work hard to achieve' (P10, gender undisclosed, 2022); 'The learning goals help me to know what is expected from me in terms of the competencies' (P24, gender undisclosed, 2022).
- It was essential to determine one's learning needs: 'The question describes learning goals, so I determine my learning needs first' [...] what I need to know' (P36, gender undisclosed, 2022); 'I do not need to wait for someone to tell me. I take my book and study' (P11, gender undisclosed, 2022).
- Taking responsibility for own learning and persistence in learning were mentioned: 'I take ownership of my own study; I do not rely on someone [else]' (P36, gender undisclosed, 2022); 'I practice even not told by the teacher' (P10, gender undisclosed, 2022); 'I make corrections on my own, do homework, study at night and during weekends' (P27, gender undisclosed, 2022); 'I do not need to wait for someone else to tell me. I check what to revise [...] I do my work on my own if there is no teacher in the class' (P11, gender undisclosed, 2022).
- Evaluate whether learning goals were achieved: 'I want to try whatever comes my way to expand my mathematical knowledge' (P36, gender undisclosed, 2022); 'I enjoy challenging problems very much, they help me to learn new things, avoid making noise or go outside to play' (P24, gender undisclosed, 2022); 'Sometimes there are many ways to solve a problem and you may get different answers, so I compare them and select the correct one' (P10, gender undisclosed, 2022); 'I enjoy new challenges; they enable me to think critical[ly]' (P14, gender undisclosed, 2022).

## ■ Discussion of the findings

Some responses regarding how problem-based tasks contributed to learners' metacognitive thinking are discussed (Research Question 1). The use of PBL tasks necessitates the collaboration of members to solve real-world problems. Apart from a brief introduction to PBL and group work, Grade 7 learners had no prior exposure to PBL and therefore initially struggled to work together on mathematics problems. The learners also experienced some tension in the group, and one learner

noted, 'I don't like group work because all group members get marks even those who did not do anything'. The learners reflected on their experiences and faced numerous challenges in working on the PBL tasks, such as language barriers, insufficient subject knowledge, a lack of resources and attitudes of learners towards group work. One learner mentioned, '[l]anguage is a problem; in most cases I do not understand the problem. I do not know what is being asked'. Moreover, several learners had personal challenges in compiling a questionnaire, not knowing what to do, struggling to deal with large numbers and not knowing how to select the correct answer.

However, metacognitive thinking was illustrated, as several learners were able to plan and set goals, monitor their thought processes, evaluate their answers and make corrections to problems. Findings indicate that the following metacognitive activities took place: re-read the question; checked whether it had been answered; and felt safe to make mistakes as group members assisted. Learners were required to evaluate their solutions and reflect on their thinking to solve the mathematics problems. Such thinking is in line with scholars who argue that effective metacognitive strategies are crucial for learning mathematics (see Fitrawati 2014, p. 162; Xenofontos & Andrews 2014, p. 279). In addition, PBL tasks allowed Grade 7 learners to participate actively in their learning process by choosing their own strategy for executing tasks. During the process, they made certain discoveries that they most likely will remember better. Lee (2021, p. 154) asserts that reflective thinking is one of five ways of mental activity from which mathematical understanding emerges and further argues that encouraging learners to solve problems in multiple ways prompts them to reflect on their approaches and establish connections between the different solutions. Such thinking significantly enhances learners' conceptual understanding (Lee 2021, p. 158). From the findings, it became clear that PBL tasks contributed to the development of most learners' metacognitive thinking.

The second research question investigated the nature of the participating Grade 7 learners' metacognitive thinking when solving mathematics problems. Participants indicated that they searched for information from various resources and planned the tasks by keeping the goals in mind and by being aware of the learning needs to complete the task. They established high expectations, set clear goals, focused to achieve them and determined what had to be done to solve the problems. One participant mentioned, 'I searched for information about writing the number of learners as degrees (angles) to draw the pie chart' and 'I looked for graph-related information'. Participants monitored their activities and applied various strategies, for example: 'If I use different ways and don't get the same answers, I compare

them and select carefully'; 'I ask myself what I need to solve the problem [...] double check if correct'.

Furthermore, learners reflected on their thinking. Although it 'was not easy', group members supported each other and made corrections as needed. Learners also evaluated their answers:

- 'I evaluate by re-reading the question and check if I answered what was asked'.
- 'I judge the answer and make sure I [have] answered properly'.

Learners also identified some errors and realised that assessing solutions leads to valuable insights regarding mathematical thinking. From the above, it was evident that learners monitored and regulated their thought processes, and as a result, they accomplished their tasks. The findings align with those by Gómez-Chacón et al. (2023, no page) and Erbay and Güner (2021, p. 718) regarding the importance and outcome of metacognitive thinking and regulation when confronted with real-world mathematics problems.

Finally, the role of metacognitive thinking in the development of SDL was explored (3rd Research Question). Several learners indicated the importance of determining their learning needs. For instance, they sought formulae for calculating the area of squares and rectangles, determined how to compile a questionnaire and searched how to represent learner numbers as degrees in the pie chart. The participating Grade 7 learners set learning goals to address the problems and exchanged ideas and thoughts on how to calculate the area. One learner noted, 'I establish high expectation[s] and clear goal[s], work hard to achieve' while another determined what was expected.

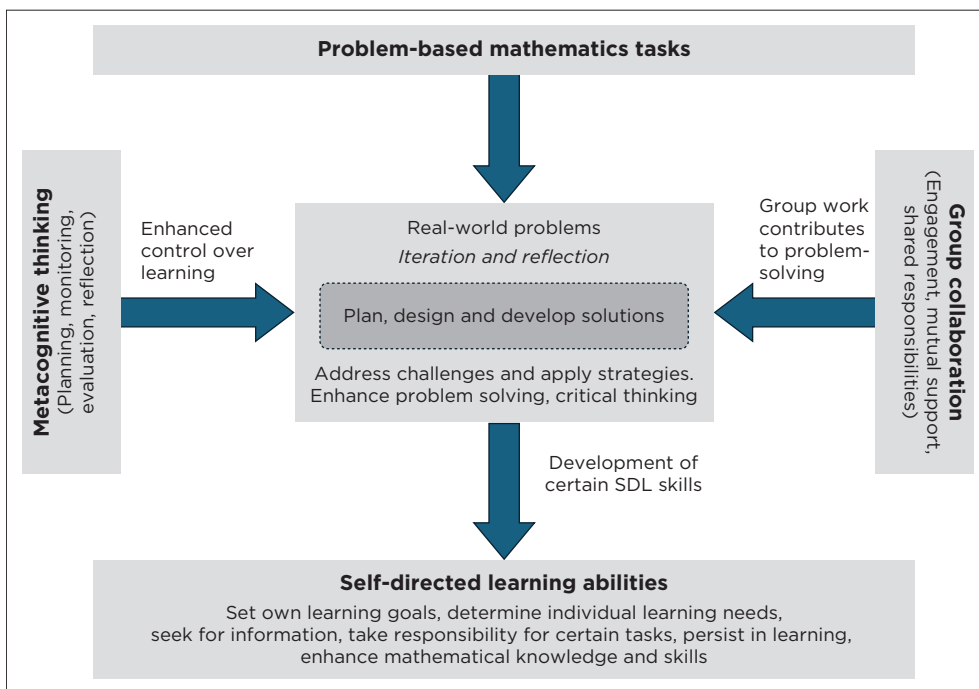
Furthermore, certain characteristics of SDL emerged from the findings as detailed in the literature review, namely responsibility in learning, ownership of learning and reflection on one's thinking. Participation relied on learners' own responsibility and active involvement. Being accountable was evident from the following: took ownership of own study, did not rely on anyone else, made own corrections, studied in the evenings and during weekends, and expanded own mathematical knowledge. Participants also indicated persistence: 'I do not need to wait for somebody to tell me. I take my book and study' and 'I want to try whatever comes my way to expand my mathematical knowledge'. Despite facing difficulties with challenging tasks, participants reflected and emphasised that this type of thinking aided them in establishing connections between their existing knowledge and what they needed to learn, as also mentioned by Cheng (2016). Likewise, participants emphasised the significance of juxtaposing various responses to a given question to make a well-informed decision. Such engagements are crucial in the realm of mathematics, as they foster critical

thinking and problem-solving (Ghomi, Moslemi & Mohammadi 2016, p. 248; Karatas & Arpacı 2021, p. 13; Ramadhanti & Yanda 2021, p. 200).

As a result of implementing metacognitive thinking in the PBL tasks, Grade 7 learners developed several skills while solving mathematics problems, such as reflective thinking, assessing and evaluating strategies and outcomes, cognitive thinking, setting learning goals and determining learning needs, learning responsibility and persistence. The implementation of PBL tasks enabled the participating learners to cultivate responsibility in their own learning.

## ■ Synthesis of metacognition in problem-based tasks

Figure 8.3 provides an overview and presents the integrated findings of this study. On the left, it highlights the importance of metacognitive thinking in all aspects of problem-solving and enhances control over learning. Additionally, group collaboration (on the right) assists learners through mutual support and shared responsibility in addressing challenges. Activities of planning, design and development require several iterations and reflection until the problem is solved and the outcomes are achieved.



Source: Own interpretation, second author.

Key: SDL, self-directed learning.

**FIGURE 8.3:** Integrated findings of this study.

As a result, these activities foster self-directed skill development, enable learners to persist in their endeavours, promote responsibility and enhance the development of essential mathematical competences regarding real-world problems.

## ■ Conclusion

This chapter addressed how Grade 7 learners in Namibia applied metacognitive thinking to assist in solving problem-based tasks in mathematics. A thematic data analysis method was developed, and this is considered a methodological contribution to this chapter. The findings indicate that mathematics problem-based tasks enhanced learners' metacognitive thinking skills and their ability to regulate their own cognitive thinking. Several examples of SDL abilities also emerged from the study. In addition, the integrated findings were visually presented.

Unfortunately, only 36 learners participated in this qualitative study and findings can therefore not be generalised. The use of PBL tasks in primary school mathematics may challenge teachers to consider it as an appropriate strategy for mathematics learning in the future phases.



# Developing learners' algebraic thinking through metacognitive strategies and mathematical language

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## ■ Abstract

The ability to think algebraically is an important facet of mathematics learning and problem-solving. Worldwide, various educational stakeholders have raised their concern regarding the level of learners' algebraic thinking. This chapter discusses the use of mathematical language and metacognitive strategies in fostering learners' algebraic thinking. A design-based research

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approach, founded on a social constructivist research paradigm, was followed. The participants were one cohort of 37 Grade 7 mathematics learners at a dual-medium, multicultural school. They had to complete a vocabulary test on algebraic concepts and operations, followed by a written algebraic task, while the researcher observed them during mathematical activities. She exposed the learners to 10 metacognitive strategies as part of the class activities. Fourteen participants were purposively sampled for task-based interviews based on their performance in the vocabulary test. Results showed that the correct use of mathematical language and appropriate metacognitive strategies contributed to the development of learners' algebraic thinking. The researcher developed a metacognitive strategy wheel that could assist teachers in exposing their learners to metacognitive strategies and the appropriate use thereof.

## ■ Introduction

Globally, the development of learners' algebraic thinking is a source of concern (Chimoni, Pitta-Pantazi & Christo 2018, p. 57; Pournara 2020; Powell, Gilbert & Fuchs 2019). Although algebra is considered the 'gatekeeper' for mathematics, many learners struggle with algebra (Wilkinson 2019, p. 10). Concern is raised that the foundation for algebra is not properly laid in Grade 7, which marks the transition from primary to secondary school (Demonty, Vlassis & Fagnant 2018, p. 2). The aim of this study is to address the problem of learners having poor algebraic thinking skills.

Content knowledge on its own appears to be insufficient to equip learners with 21st-century skills (Breed & Bailey 2018, p. 1). To perform in mathematics, learners must also be familiar with the correct mathematical language and be able to think algebraically. Litke (2020, p. 1) opines that algebraic thinking is enhanced if the teacher explicitly uses the correct mathematical language in the classroom. This means that mathematical language plays a crucial role in the development of algebraic thinking (Chimoni et al. 2019, p. 58).

Although South African learners are exposed to algebraic reasoning in the earlier grades, they encounter formal algebra for the first time in Grade 7 in the mathematics curriculum (Department of Basic Education [DBE] 2011). Algebraic thinking develops through four dimensions, namely forms of reasoning, algebraic processes, general content strings and algebraic concepts (Pitta-Pantazi, Chimoni & Christou 2019, p. 966). Metacognition is viewed as 'knowledge and cognition about cognitive phenomena' (Flavell 1979, p. 906). Metacognition stems from individuals' understanding and awareness of their own cognition and regulation.

In addition, metacognitive regulation (i.e. planning, monitoring, evaluation and reflection) contributes to the development of algebraic thinking, as it empowers learners to attain higher-order thinking skills (Molin et al. 2020, p. 3).

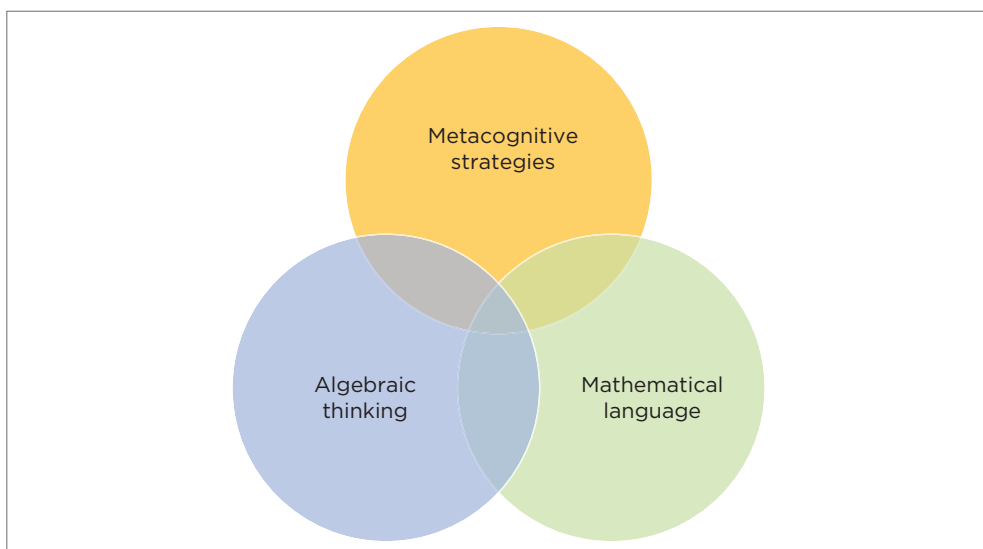
In light of the above, the aim of this chapter is to report on how the use of metacognitive strategies fostered Grade 7 learners' algebraic thinking. These research questions directed the research:

- Which metacognitive strategies play a role in the development of Grade 7 learners' algebraic thinking?
- How does the algebraic thinking of Grade 7 learners develop?
- What is the role of mathematical language in the development of Grade 7 learners' algebraic thinking?

To achieve the specified aim, the subsequent sections provide a discussion of metacognitive strategies, how algebraic thinking develops, the three types of mathematical language needed to develop algebraic thinking and their role in fostering algebraic thinking.

## ■ Conceptual-theoretical framework

The concepts of metacognitive strategies, algebraic thinking and mathematical language underpin this chapter. These concepts are interrelated as displayed in Figure 9.1.



Source: First author's own design

**FIGURE 9.1:** The interconnectedness between related concepts.

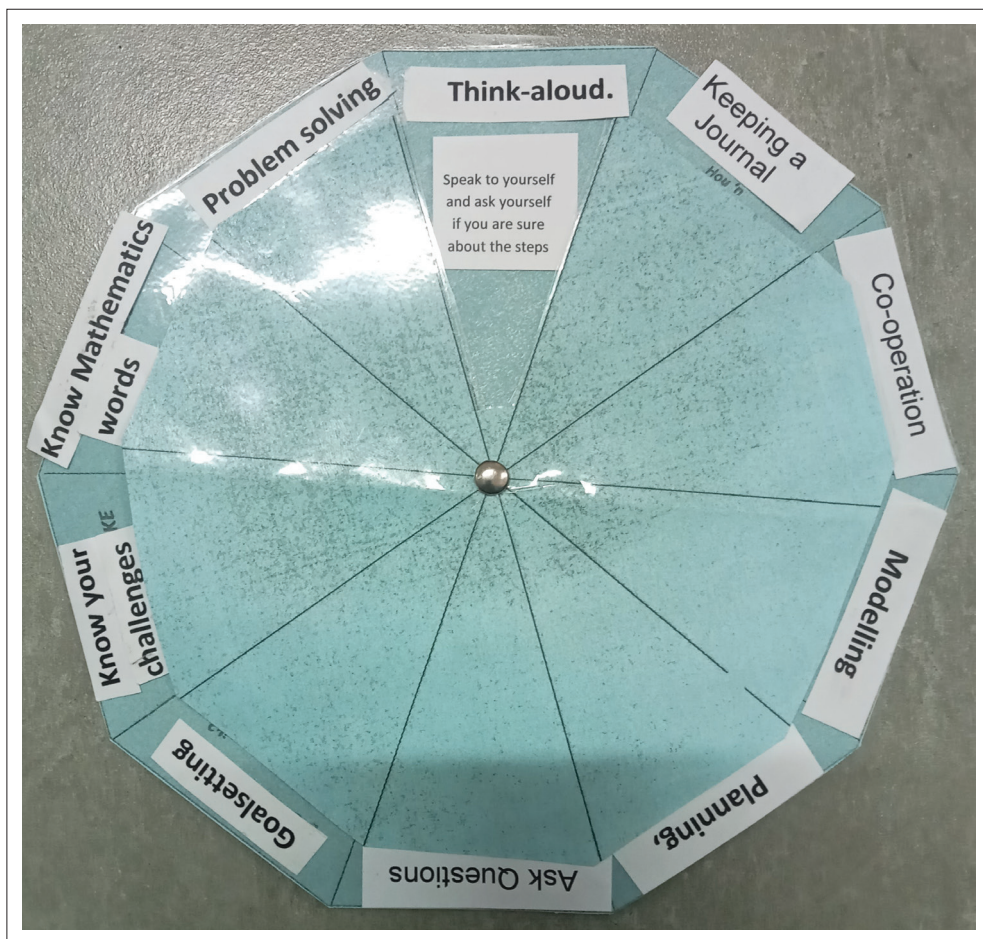
## ■ Metacognitive thinking for developing algebraic thinking

Primary school learners are not necessarily aware of their metacognitive thinking and the use of metacognitive strategies. Therefore, teachers need to explicitly facilitate the use of metacognitive strategies in the classroom. Flavell (1979, p. 906) is regarded as the 'father' of metacognition, commonly described as 'thinking about one's thinking' or 'learning how to learn'. He distinguishes between three aspects of metacognition: (1) metacognitive knowledge, (2) metacognitive experiences and (3) metacognitive regulation. The focus of this chapter is on metacognitive regulation that includes planning, monitoring, evaluation and reflection (Cornoldi 1997; O'Neil & Abedi 1996).

Planning entails selecting a suitable metacognitive strategy, for example, to predict the outcome beforehand. As learners' planning skills develop between 10 and 14 years (Grade 7), it is a suitable time to encourage them to plan (Schraw & Moshman 1995, p. 354). Monitoring is the process which controls and structures the learning aims (Öztürk 2021, p. 2). Learners can monitor their cognitive processes by employing a suitable metacognitive strategy (Flavell 1979, p. 909). Learners who can monitor their thinking processes are able to execute more challenging problems (Schraw & Moshman 1995, p. 355). Evaluation is a regulation process that verifies if the objectives were met or not. Evaluation also entails the identification of mistakes and the correction of mistakes (Öztürk 2021, p. 2). The teacher must diagnose learning difficulties, assist learners to formulate learning objectives and expose learners to metacognitive thinking (Du Toit-Brits 2018, p. 378). Reflection consists of a learner's personal knowledge, ideas and feelings (Denke, Jarson & Sinno 2020, p. 6). The teacher must provide ample opportunities for learners to reflect on their learning, specifically on algebra, as reflection develops long-term memory and problem-solving skills. Furthermore, mathematics teachers ought to use reflection to connect metacognition and algebraic thinking. Metacognitive strategies are needed to plan, monitor, reflect and evaluate one's learning (Öztürk 2021, p. 2).

In addition, teachers are expected to empower learners with self-directed learning (SDL) skills to enable them to continually plan, monitor, regulate and evaluate their own learning (Van Zyl & Mentz 2019, p. 73), so that they can adapt in a continuously changing environment (Van Zyl & Mentz 2019). As metacognition is considered a driver for, and interrelated to SDL (Shannon 2008, p. 18), learners in this study are made aware of metacognitive strategies to contribute to SDL.

The first author designed a metacognitive strategy wheel to explain metacognitive strategies to learners (see Figure 9.2) to assist them with



Source: Researcher's own design.

**FIGURE 9.2:** Metacognitive strategy wheel.

the development of algebraic thinking. The researcher specifically employed the following 10 metacognitive strategies suggested by Du Toit and Kotze (2009): keeping a journal, collaboration, modelling, planning, asking questions, goal setting, knowing one's challenges, knowing mathematics words, problem-solving strategies and thinking aloud.

The metacognitive strategy wheel consists of two decagon-shaped laminated figures, fastened on top of one another with a split pin. The decagon at the bottom shows a metacognitive strategy with the description, while the top decagon has one opening that reveals one description at a time. The researcher gave each learner a metacognitive strategy wheel while she explained each metacognitive strategy individually. She started with journal keeping and explained how one could keep a journal while

learning algebra. Collaboration is when two or more learners work together to solve an algebraic problem or to compare possible solutions to find the correct solution. Collaboration makes learners aware of their own and their peers' thought processes (Du Toit & Kotze 2009, p. 61). Shore (2021, p. 5) asserts that deeper learning can take place when learners collaborate. Modelling is when given information is plotted in a table, especially when working with patterns, or to draw a picture to solve an algebraic problem. Planning is deciding which steps or strategies to apply when solving a problem. For example, if learners must solve the equation  $8x = 2x + 4$ , the first step is to get all the variables on one side of the equals sign and all the constants on the other side if one uses the isolation method. The second step is to simplify, and the last step is to check one's answer by using the substitution method. One should ask oneself questions such as 'Why did I choose this operation? How sure am I that my solution is correct?'

Being aware of and employing suitable metacognitive strategies (as mentioned above) contributes positively to learners' reasoning abilities for the following reasons: they can determine what is needed to perform the task; they can identify the appropriate algorithms and calculations; they can predict possible results; and they can reflect on the correctness of the solution (Daher, Anabousy & Jabarin 2018, p. 293). Furthermore, metacognitive strategies empower learners to progress from concrete to abstract forms of reasoning and enable them to progress to formal algebraic thinking (Chimoni et al. 2018, p. 73).

In conclusion, teachers ought to communicate and model metacognitive strategies to learners and provide them with ample opportunities to practise these strategies. Teachers should also use the correct mathematical language for learners to learn the language themselves, as incorrect language might lead learners to failure rather than success (Sfard 2023, p. 22).

Learners who use metacognitive strategies efficiently become more self-directed (Astriani et al. 2020, p. 5). Self-directed learning develops through metacognitive strategies (Breed & Bailey 2018, p. 3). Learners who are self-directed take responsibility for their learning, are persistent and creative, and they can plan, monitor, evaluate and reflect on their learning. The teacher plays an important role as the mediator of metacognitive thinking and SDL (Molin et al. 2020, p. 1).

## ■ The development of algebraic thinking

In this chapter, the development of algebraic thinking is based on the following four dimensions: general content strands, algebraic concepts essential for the development of algebraic thinking, algebraic processes

crucial for the development of algebraic thinking and forms of reasoning (Chimoni et al. 2018, p. 60). General content strands consist of general algorithms and functional thinking. Algebraic concepts that must be developed are equality, the properties of numbers, properties of operations, variables or unknown values and symbols. Observations, generalisations, representations and testing for validity are four algebraic processes required for the execution of mathematical tasks.

Forms of reasoning consist of three sections: abductive, inductive and deductive reasoning. Abductive reasoning requires pre-knowledge (Kaplan, Gulkilik & Emul 2021, p. 817). This form of reasoning can be used as a metacognitive strategy – for example, when learners ask themselves ‘What do I already know?’. When learners estimate or guess an outcome, they apply abductive reasoning. For instance, when a learner reads the algebraic expression  $8 \times 2n = 80$  and states that the value of  $n$  must be less than 80, abductive reasoning was applied. Inductive reasoning seems to be a significant predictor of algebraic thinking (Pitta-Pantazi et al. 2019, p. 981) because it entails the generalisation of mathematical processes and formulas. Predicting a pattern is both a metacognitive strategy and inductive thinking. Deductive reasoning enables a learner to prove that a solution to an algebraic equation is correct or incorrect (Kaplan et al. 2021, p. 818).

Poor algebraic thinking in Grade 7 tends to result in poor algebraic thinking in secondary school and poor performance in mathematics in general (Daher et al. 2018, p. 295). The findings of this study are in line with the literature and confirm that algebraic thinking develops because of the use of the correct mathematical language (Biccard 2017, p. 218; Riccomini et al. 2015). Furthermore, the study also showed that the use of certain metacognitive strategies plays a significant role in Grade 7 learners’ algebraic thinking. Informed by the findings, a metacognitive strategy wheel was developed as a tool to guide teachers in supporting Grade 7 learners to develop this crucial higher-order thinking skill.

## ■ Mathematical language in the development of algebraic thinking

A language is defined as words, the pronunciation of words and the combination of words to communicate meaningfully in society (Riccomini et al. 2015, p. 236). Mathematics is a language with unique terminology, symbols and concepts essential to describe numerical, geometric and graphical relationships (DBE 2011, p. 8). Learners who do not understand the language of mathematics can be either included or excluded when it comes to understanding the subject (Robertson & Graven 2020, p. 78). A lack of knowing or understanding of mathematical language negatively

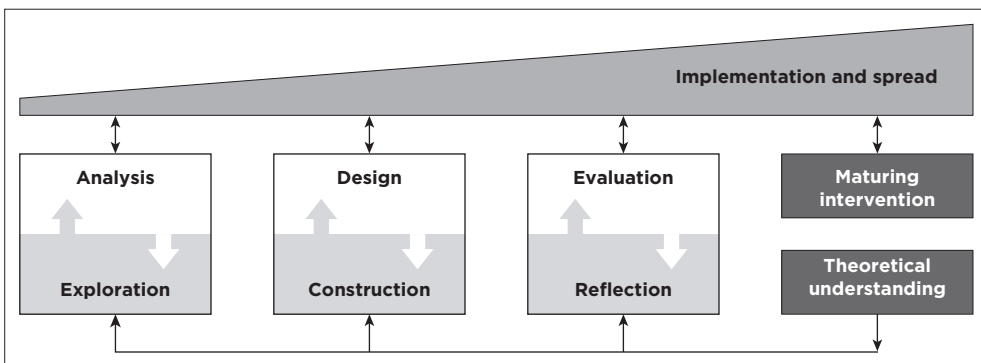
affects learners' mathematical performance (Moffett & Eaton 2019, p. 1765). Mathematical language is viewed as the building block for mathematical skills (Riccomini et al. 2015, p. 236).

Correct, specialised mathematical language is required to develop algebraic thinking. In the South African Curriculum and Assessment Policy Statement (CAPS) (DBE 2011), this specialised mathematical language is called algebraic language. As learners are introduced to formal algebra for the first time in Grade 7, algebraic language is new to these learners. Wessel (2020, p. 656) states that to develop an understanding of a mathematical concept, learners need words and phrases to acquire meaning. Mathematics educators should not take terms such as variables, constant, commutative-, associative- and distributive properties for granted. Learners need to know the meaning of algebraic words to develop algebraic thinking.

According to Wessel (2020, p. 656), class discussions should be explanatory and argumentative rather than traditional reporting. Learners should be afforded the opportunity to explain algebraic concepts in their own words, while it remains the responsibility of the mathematics teachers to lay the foundation for the conceptual understanding of mathematical concepts by focusing on vocabulary (Wessel 2020, p. 656).

## ■ Research methodology

A qualitative research design was used with a design-based research (DBR) approach against the backdrop of a social constructivist research paradigm. A key aspect of DBR is the iterative cycle of analysis, design, implementation, evaluation and revision of interventions (McKenney & Reeves 2014). McKenney and Reeves (2021, p. 86) designed a generic model for conducting DBR seen in Figure 9.3.



Source: Adapted from McKenney & Reeves 2021, p. 86.

**FIGURE 9.3:** Generic model for conducting design-based research (DBR).

The purpose of the first phase, analysing and exploration, is to understand the problem by conducting a literature review and setting goals for the study (McKenney & Reeves 2014, p. 143). The second phase, design and construction, includes a theoretical framework and description of the intervention needed to address the problem (McKenney et al. 2014, p. 140). In this study, the design and construction phase were when the metacognitive strategy wheel was developed. The researcher identified 10 suitable metacognitive strategies and designed the metacognitive strategy wheel. The intervention developed was evaluated and reflected on in the third phase. These phases repeated in iterative cycles throughout the study.

Design-based research is ideal for educational research practice because it is used to investigate real-life settings (Parmaxi & Zaphiris 2020, p. 257). Furthermore, DBR builds a bridge between theory and teaching practice (Bakker & Van Eerde 2015, p. 430). A teacher's teaching practice can be adapted to develop learners' metacognitive strategies and to foster their algebraic thinking. The purpose of DBR is to describe, compare, evaluate, explain and advise (Bakker & Van Eerde 2015, p. 431).

The first cycle of analysis, design, implementation and evaluation started with a vocabulary test. The second cycle involved a written task and then task-based interviews. The population consisted of Grade 7 learners at a dual-medium, multicultural school. One Grade 7 class ( $N = 37$ ), taught by the first author, was conveniently sampled. The researcher obtained informed consent from the parents/guardians of the participants.

The data gathered from the vocabulary test guided the classification of participants. The four learners with the best results in the vocabulary test were identified as Participants A1-A4. Participants B1-B5 were learners who performed average in the vocabulary test. Participants C1-C5 responded mostly incorrect to the terms in the vocabulary test. Table 9.1 displays the information of the 14 participants.

To determine the sample, all the participants completed the vocabulary test. The sample consisted of five learners who did well in the vocabulary test, five learners who performed average in the vocabulary test and five learners who performed poorly in the vocabulary test. One of the top performers left the school and the study continued with a sample of 14 participants. The remaining 22 learners participated in all class activities, but their data were not used in the data analysis.

## ■ Ethical considerations

As the participants were minors, the study was approved by EMELTEN-REC Research Ethics Committee of the North-West University (Ethics number: NWU

**TABLE 9.1:** Codes, gender and ages of the participants.

Participant code	Gender	Age
A1	Girl	12
A2	Girl	13
A3	Boy	13
A4	Boy	14
B1	Girl	13
B2	Boy	12
B3	Boy	13
B4	Boy	13
B5	Girl	13
C1	Boy	13
C2	Girl	12
C3	Girl	14
C4	Girl	13
C5	Boy	14

Source: First author's data.

00001-21-A2). The DBE, school principal and school governing body (SGB) of the school granted written permission to conduct the study at the school. An independent person assisted the first author to obtain signed informed consent from the parents and informed assent from the participants. Participants received the codes A1–A4, B1–B5 and C1–C5 (see Table 9.1). Confidentiality was assured by using these codes. Hard copies of data were kept safely, and electronic documents were password-protected on a computer.

## ■ Data collection and activities

The data collection commenced with a vocabulary test consisting of mathematical terms, concepts and operations which the participants had to explain or define. The vocabulary test was developed by using mathematical terms used in the curriculum. Firstly, new terminology regarding algebraic language was used, then mathematical terminology involving operations and, lastly, general mathematical terms. In this way, the level of learners' mathematical language was assessed, and participants for the task-based interviews were identified. Five learners with strong mathematical language skills were chosen as participants and were coded as 'group A'. The learner with the best mathematical language is A1. Five learners with average mathematical language skills were chosen for 'group B'. Five learners with no mathematical language skills form the 'C group', but one learner from the 'A group' left the school and the study continued with the remaining 14 participants. The list of words was followed by written tasks on algebraic problems. The tasks were based on the four

dimensions of algebraic thinking, namely, general content strings, algebraic concepts, algebraic processes and reasoning forms. Observations of learner activities were done to collect data regarding learners' algebraic thinking and metacognitive strategies. The researcher analysed these tasks with respect to the various forms of algebraic reasoning the participants used. Task-based interviews with the 14 selected participants followed this algebraic task, with a focus on learners' use of metacognitive strategies during mathematical problem-solving. The interviews were recorded, transcribed and analysed.

## ■ Data analysis

The iterative cycles of DBR continued in the data analysis process. The data were analysed in various ways, depending on the nature of the collected data. The vocabulary test was assessed, and answers were analysed as correct, partially correct and incorrect. A second DBR cycle started when the first author developed the algebraic task. The algebraic task was assessed with a rubric according to the four dimensions of algebraic thinking. Observations of learner activities were analysed by means of discourse analysis to explore mathematical language as well as algebraic reasoning. The last cycle of DBR was the task-based interviews. Task-based interviews were transcribed verbatim and analysed to identify the metacognitive strategies used by the participants. The findings are presented in the following section.

## ■ Presentation of the findings

In this section, the findings that emerged from the vocabulary test, the written algebraic task and the task-based interviews are presented, according to the iterative cycles of DBR.

### □ Vocabulary test

The results of the vocabulary test were analysed, and the first author evaluated the data to complete the DBR cycle (see Figure 9.3). Fluency in mathematical language contributes to the development of algebraic thinking (Litke 2020, p. 1). The researcher divided mathematical language into three sections to investigate: algebraic language (new in Grade 7); vocabulary regarding operations; and general algebraic language. All the mathematical terms in the vocabulary test are words found in the Grade 7 CAPS curriculum. Algebraic language includes terms such as constant and variable whereas terms for mathematical operations include sum, difference, product and quotient. A few general language terms are prime number, factor, commutative, ratio, rate and percentage among others.

After a lesson on algebraic language, the participants completed a vocabulary test where they had to write or draw a description of each term. The definitions of terms could vary because learners communicate in an informal manner. The descriptions were marked as correct, partially correct, or incorrect.

Only participants A2 (girl, Oct 2021), B1 (girl, Oct 2021), B4 (boy, Oct 2021) and B5 (girl, Oct 2021) were able to describe the term algebraic language correctly. An example of a correct description is as follows: 'to use numbers and variables (letters) and symbols to represent relationships'. Some participants (A1, girl, Oct 2021; A3, boy, Oct 2021; C1, boy, Oct 2021 and C2, girl, Oct 2021) described the term partially correct by writing something like 'the use of letters in a sum'. Four participants (A2, girl, Oct 2021; B1, girl, Oct 2021; B4, boy, Oct 2021 and B5, girl, Oct 2021) who were able to describe algebraic language knew the meaning of constant, but only two participants were able to describe variable correctly. Partially correct descriptions included 'x, y and z' or 'variables are small (not capital) letters instead of a symbol or letter in the place of an unknown value'.

It is expected of Grade 7 learners to know terms regarding operations, because these terms are used from the Foundation Phase; yet, three participants could not describe the term sum of, and seven participants did not describe the term difference correctly. Product was incorrectly associated with making something: 'If you make something, it is called a product'.

General mathematical terms, such as prime numbers, compound numbers, multiples and factors, are not new to Grade 7 learners. Some learners (C3, girl, Oct 2021; C4, girl, Oct 2021 and C5, boy, Oct 2021) in Grade 7 do not know the difference between the terms multiple and factor. It is most concerning that only one participant (A4, boy, Oct 2021) knew a suitable description for the term equal. Partially correct descriptions were 'the same' instead of 'the value on the left side of the equal(s) sign is the same as the value on the right side of the equal(s) sign'. An incorrect description was 'the answer to the sum'. Many Grade 7 learners associate the term equal with the word answer. Moreover, eight learners (A1, girl, Oct 2021; A2, girl, Oct 2021; A3, boy, Oct 2021; B1, girl, Oct 2021; B3, boy, Oct 2021; B5, girl, Oct 2021; C1, boy, Oct 2012 and C2, girl, Oct 2021) were able to describe the term whole numbers and give an example. A partially correct answer was '0, 1, 2, 3, 4...', without a verbal explanation. Whole numbers is part of the number concept necessary for the development of algebraic thinking (Pitta-Pantazi et al. 2019, p. 967). Only two learners (A2, girl, Oct 2021 and B5, girl, Oct 2021) were able to describe inverse operations. Partially correct descriptions for the term inverse operations were single words such as swap, opposite and undo. Learners with better mathematical

vocabulary (A1, girl, Oct 2021; A2, girl, Oct 2021; A3, boy, Oct 2021; A4, boy, Oct 2021; B1, girl, Oct 2021 and B, boy, Oct 2021) were able to explain the order of operation in their own words.

Properties of operations (the commutative, associative and distributive properties) are fundamental algebraic concepts (Chimoni et al. 2018, p. 60), but only five learners (A1, girl, Oct 2021; A2, girl, Oct 2021; A3, boy, Oct 2021; A4, boy, Oct 2021 and B1, girl, Oct 2021) were able to describe the term commutative property, and two of the five (A3, boy, Oct 2021 and A4, boy, Oct 2021) learners were able to describe the term associative property. Four of the learners (A2, girl, Oct 2021; A4, boy, Oct 2021; B4, boy, Oct 2021 and B5, girl, Oct 2021) did not try to describe the term distributive property. If a learner described ratio as a comparison of the same measuring units, it was considered as correct. An example of a ratio was considered as partially correct. Some learners (A1, girl, Oct 2021; A2, girl, Oct 2021 and A3, boy, Oct 2021) who described rate correctly associated the term with the word 'per' – for example, R10 per litre. These learners knew it was a comparison between two different measuring units, like Rand per kilogram.

The use of the correct mathematical language is a metacognitive strategy. The findings showed that learners with good mathematical language are more likely to employ metacognitive strategies. Using the correct mathematical language assists in developing algebraic thinking (Kızıltoprak & Köse 2017, p. 131).

There is a positive correlation between mathematics language and mathematics performance (Çelik 2020, p. 328) and learners require mathematics language for algebraic thinking. The use of symbols and mathematical language forms a cornerstone for explaining mathematical ideas rationally and using mathematical terminology accurately (Çelik 2020). The next data collection method involved a written task with algebraic problems.

## □ Written task

The purpose of the written task was to investigate how Grade 7 learners' algebraic thinking developed. The written task was divided into four sections according to the dimensions of developing algebraic thinking, namely: general content strands (see § 3.3.2.1), algebraic concepts (see § 3.3.2.2), algebraic processes (see § 3.3.2.3) and reasoning forms (see § 3.3.2.4) (Chimoni et al. 2018, p. 58).

The researcher requested the learners to predict the mark they thought they would achieve (in pencil) on the assessments before submitting them, to make them aware of their own thoughts about their learning. To predict an outcome is a metacognitive strategy which contributes to algebraic

thinking (2.1) (Stephens et al. 2017, p. 144). In most cases, they predicted their results correctly and were aware of where they made mistakes. Knowing one's challenges helps one to pay more attention to and practice of a specific skill. Learners were comfortable in solving algebraic equations with variables on the left-hand side of the equal sign. Knowing the meaning of mathematics words is an important metacognitive strategy not only for algebra but also for all mathematics topics. If learners do not know important terms such as variable, constant, inverse operation, commutative-, associative- or distributive properties, they tend to struggle with developing algebraic thinking. The researcher gave each learner a blank index book to use as a mathematics dictionary. During each new lesson, the learners had an opportunity to write new words and the meaning in their maths dictionary. Think aloud is a metacognitive strategy that enhances conceptual knowledge and is needed for the development of algebraic thinking (Bonner et al. 2021, p. 27).

When learners came across an algebraic equation such as  $10 = x + 2$ , they could exchange the variable with the word what and read it aloud (10 equals what plus two?). Reading aloud also assists in the development of algebraic thinking.

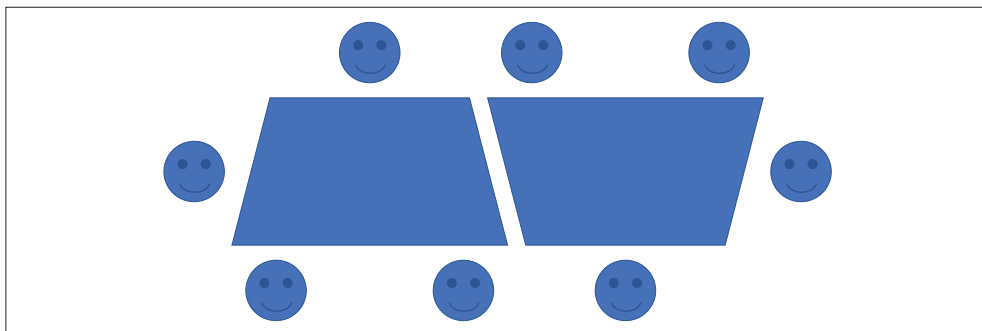
## □ General content strands

The first dimension of developing algebraic thinking is general content strands, which consist of general algorithms and functional thinking (Pitta-Pantazi et al. 2019, p. 967). As general content strands form part of the mathematics curriculum from the Foundation Phase, it is not new to Grade 7 learners.

The question in the written task to investigate general algorithms was as follows:

Five children sit around a trapezium-shaped table. If two trapezium-shaped tables stand next to each other, eight children can sit around the tables. How many children can sit around three tables? How many children can sit around 10 tables? Why do you say so? (See Figure 9.4)

Three (A2, girl, Oct 2021; A4, boy, Oct 2021 and B3, boy, Oct 2021) of the 14 participants calculated the solution to the problem correctly. Some (A1, girl, Oct 2021; B5, girl, Oct 2021 and C1, boy, Oct 2021) participants drew a model of the problem but still calculated it incorrectly. One participant, A3 (boy, Oct 2021), drew a table and got the correct answer; however, her way of writing was not mathematically correct. Participants (C2, girl, Oct 2021; C3, girl, Oct 2021 and C5, boy, Oct 2021) who responded incorrectly said the number of tables multiplied by five because five children can sit around one table. The second part of the general content



Source: Adapted from Hourigan & Leavy 2015, p. 38.

**FIGURE 9.4:** Geometric repeating pattern starting with two trapezium tables with eight children.

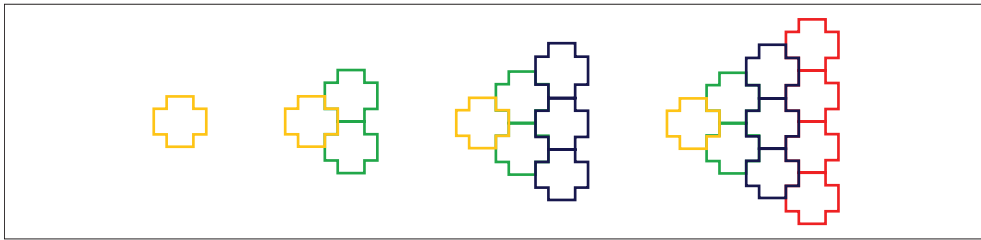
strand is functional thinking, which refers to the relationship between co-varying quantities (Chimoni et al. 2018, p. 59). Functional thinking is divided into three modes: recursive, covariation and correspondence (Stephens et al. 2017, p. 145). To investigate recursive patterns in the written task, the question was as follows:

Albert collects marbles. He receives marbles daily. The number of marbles increases daily in a certain pattern. On the first day, he got five marbles. On day two, he received 13 marbles, and on day three, he received 21 marbles. How many marbles will he receive on day 12? Why do you say so?

Seven participants (A1, girl, Oct 2021; A2, girl, Oct 2021; A4, boy, Oct 2021; B1, girl, Oct 2021; B3, boy, Oct 2021; B5, girl, Oct 2021 and C2, girl, Oct 2021) preferred to plot the given information in a table and then they recognised that the marbles increased daily by eight marbles. Participants (A1, girl, Oct 2021; A2, girl, Oct 2021; A4, boy, Oct 2021; B3, boy, Oct 2021 and B5, girl, Oct 2021) who extended the pattern up to day 12 calculated the pattern correctly, but only two participants (A1, girl, Oct 2021 and A2, girl, Oct 2021) were able to write the pattern in the correct formula, namely,  $8n-3$ .

Covariation relations is the comparison of two quantities that vary in relationship to one another (Stephens et al. 2017, p. 145). To investigate Grade 7 learners' understanding of covariation relations, the researcher used a triangular number pattern in the written task (see Figure 9.5).

Most (A1, girl, Oct 2021; A2, girl, Oct 2021; A3, boy, Oct 2021; B2, boy, Oct 2021; B3, boy, Oct 2021 and B4, boy, Oct 2021) participants were able to extend the pattern, but no participant was able to write the correct formula for the pattern. Correct mathematical language plays a crucial role in guiding learners to be able to understand the pattern (Verschaffel et al. 2020, p. 9). Terms like increase, extend and repeat the pattern must be



Source: First author's own design.

**FIGURE 9.5:** Geometric growing pattern from the written task.

clear to learners for them to be able to understand patterns. Modelling is a suitable metacognitive strategy to solve this problem. To extend the pattern is the correct modelling, but learners need mathematical language to expand their metacognition.

Correspondence relation is when the independent variable associates with the dependent variable (Biza et al. 2019, p. 1107). To investigate correspondence relations in the written task, the researcher asked the following: 'John is three years older than his sister, Suzie. Suzie is 14 years old. Write an algebraic equation to calculate John's age'. All the participants used the variable  $x$ , and some participants (A1, girl, Oct 2021; A2, girl, Oct 2021; A3, boy, Oct 2021; A4, boy, Oct 2021; B2, boy, Oct 2021; B4, boy, Oct 2021; B5, girl, Oct 2021 and C1, boy, Oct 2021) calculated John's age as 17 years. The participants who (B1, girl, Oct 2021; B3, boy, Oct 2021; C2, girl, Oct 2021; C3, girl, Oct 2021; C4, girl, Oct 2021 and C5, boy, Oct 2021) calculated John's age incorrectly said he was 11 years old. In other words, they did not do the inverse operation correctly. To evaluate if the response is correct is another metacognitive strategy that will improve learners' algebraic thinking (2.1). During the intervention, the researcher enabled these participants to use metacognitive strategies to ask themselves 'Should I add or subtract?' The researcher motivated learners to ask the questions mentioned above to develop their metacognitive thinking. (Metacognitive strategies are discussed in detail under task-based interviews.) Participants with well-developed general algorithmic and functional thought struggled less with algebraic thinking and that is why the researcher deems general content strands important for developing algebraic thinking.

## □ Algebraic concepts

Algebraic concepts are the second dimension of developing algebraic thinking and consist of equality, properties of numbers, properties of operation, variables and unknown values and symbols (Chimoni et al. 2018, p. 59).

Algebraic content – for example, equality, properties of numbers and properties of operations – are in the mathematics curriculum from the Foundation Phase. Correct mathematical language should be integrated when new topics on algebraic content (for example, variables) are taught (Wessel 2020, p. 365).

Equality is the first element of algebraic content. Through class observations and class discussions, the researcher noticed that almost all the participants associated equality with the outcomes of an operation. Participants commented that ‘equals mean(s) the answer of a sum’. In other research, learners called the equals sign ‘the do symbol’ or ‘the add-everything-together symbol’ (Fyfe, Matthews & Amsel 2020, p. 66). Before the written task, the researcher intervened with a ‘balancing scale’ lesson. Fyfe et al. (2020, p. 67) suggest that using a balancing scale to communicate that both sides of the equation should remain equivalent or the same, would bridge the gap. Nevertheless, only five (A1, girl, Oct 2021; A2, girl, Oct 2021; A3, boy, Oct 2021; A4, boy, Oct 2021 and B1, girl, Oct 2021) participants were able to apply the knowledge from the balancing scale lesson in the written task. One of the questions in the written task to investigate equality was as follows: ‘State whether the equation is true or false:  $5 + 6 = 11 - 1$ ’. Three participants (B5, C3 and C5) stated that the equation was true, because they stopped reading after the 11.

Properties of numbers (the second element of algebraic content) include the addition property of 0 and the multiplication property of 1. Participants were familiar with these mentioned properties of numbers, and four participants (C2, girl, Oct 2021; C3, girl, Oct 2021; C4, girl, Oct 2021 and C5, boy, Oct 2021) stated that  $0 \div 3 = 0$  was true, but they also stated that  $3 \div 0 = 0$  was true. Only four other participants (A1, girl, Oct 2021; boy, Oct 2021; A3, boy, Oct 2021; A4, boy, Oct 2021 and B3, boy, Oct 2021) used the word undefined correctly. One participant thought that  $3 \div 0 = 0$ . Learners first need to understand the properties of numbers before algebraic thinking can be developed (Pourdavood, McCarthy & McCafferty 2020, p. 243).

The commutative, associative and distributive properties are the properties of operations needed to develop Grade 7 learners’ algebraic thinking (Pitta-Pantazi et al. 2019, p. 667). The question in the written task on commutative property was as follows: ‘Is the commutative property applicable to subtraction? Write an algebraic equation to prove your answer’. Four participants (C1, boy, Oct 2021; C2, girl, Oct 2021; C4, girl, Oct 2021 and C5, boy, Oct 2021) stated that the commutative property was applicable to subtraction. During class observations and class discussions, the researcher noticed that learners expected the distributive property to be applicable to subtraction and division, but because commutative and associative are applicable to addition and multiplication, they expected the opposite. These incorrect ideas of learners on the properties of operations

$x - 110 = 175$   
 $x - 110 + 110 = 175 + 110$   
 $175 + 110 = 285$   
 $x = 285$  ✓

d  $187 = 154 + y$   
 $187 = 154 + y - y$   
 $187 - y = 154$  ✗

Source: First author's data: Participant B12, boy, Oct 2021.

**FIGURE 9.6:** Participant's challenge with a variable on the right side of an equation.

and metacognitive strategies were addressed in further class discussions before the task-based interviews commenced.

Variables and unknown values are critical benchmarks of algebraic content that are needed for Grade 7 learners to develop algebraic thinking (Ayieko 2018, p. 32). Data from the written task showed that participants made sense of variables on the left side of the equals sign but struggled with variables on the right side of the equals sign, as seen in Figure 9.6. Learners needed more opportunities to practise solving unknown values (Ayieko 2018, p. 31).

Florio (2020, p. 4) states that symbols of algebraic language form part of the development of algebraic thinking. The 'minus symbol' was one of the symbols that was investigated in the written task. Learners understood that the minus symbol was used for subtraction, but some participants still struggled with the subtraction symbol to indicate negative numbers in an algebraic expression. Exponents and roots are new topics in the Grade 7 curriculum, and the researcher wanted to investigate symbols on these topics in the written task. The question in the written task was as follows: 'Rewrite the equation in algebraic language:  $x + x + x + x = 8$ '. The correct response would be  $4x = 8$ . Some participants (B1, B4 and C1) wrote  $x^4 = 8$  or  $4^x = 8$ . Participants did not know the difference between  $\sqrt{x}$  and  $\sqrt[3]{x}$ . It is of critical importance that mathematics teachers use the correct mathematical language (and symbols) to teach algebra to their learners (Florio 2020, p. 2).

## □ Algebraic processes

Algebraic processes are the third dimension of developing algebraic thinking and consist of observation, generalisation, presentation and testing for validation (Chimoni et al. 2018, p. 58). Number patterns were used to investigate participants' observation processes in the written task. Participants observed the pattern and those who did better in the vocabulary test (the A group) were able to extend the given pattern.

Generalisation was the second algebraic process in the written task. The same pattern was used to investigate observation and generalisation. This given pattern's formula was  $4n + 1$  and most participants were able to state that the pattern increased by four each time. In other words, they were able to get to  $4n$ , but they struggled with  $+1$ .

Presentations in table format were investigated in several questions in the written task, and the researcher noted that the participants made sense of this format. However, some participants (B3, boy, Oct 2021; B4, boy, Oct 2021; C1, boy, Oct 2021 and C2, girl, Oct 2021) struggled to calculate the  $x$  value if the  $y$  value was given. In an input/output presentation, all participants could calculate the output, but only half (seven) of the participants (A1, girl, Oct 2021; A2, girl, Oct 2021; A3, boy, Oct 2021; A4, boy, Oct 2021; B1, girl, Oct 2021; B2, boy, Oct 2021 and B5, girl, 2021) could calculate the input. Participants who were unable to calculate the input experienced challenges with doing the inverse operation. If participants applied metacognitive strategies, for example, monitoring and evaluating their responses, they should recognise their mistakes. Asking themselves 'what did I do wrong and how should I correct it?' is the next metacognitive strategy that will improve the development of algebraic thinking.

In the written task, to investigate how learners tested for validation, participants had to state whether the given statement was true or false. One of the statements was '[an] odd number minus an even number always equals an odd number'. All the participants only tested one set of whole numbers and stated that the statement was true. Another statement that participants needed to test for validation was '[if] you multiply two numbers, the product will always be more than the two numbers'. Six participants (A1, girl, Oct 2021; A2, girl, Oct 2021; A3, boy, Oct 2021; B1, girl, Oct 2021; B2, boy, Oct 2021 and B4, boy, Oct 2021) started with whole numbers, then tested fractions and stated that the statement was false because of the word 'always'. Five participants (A4, boy, Oct 2021; B3, boy, Oct 2021; B5, girl, Oct 2021; C2, girl, Oct 2021 and C3, girl, Oct 2021) only wrote true or false without any calculations to test for validity. The researcher noted that participants focused on the product rather than on the process of testing for validation, because they only used one or two examples to test the statement. They wanted to get to the answer as quickly as possible with the least possible effort. Metacognitive strategies empower learners to focus more on the process, to get a better result, rather than to rush to get any solution. Learners should be motivated to use whole numbers, decimal numbers, fractions and integers to test the statement.

Some algebraic processes are new in Grade 7 and mathematics educators should not expect learners to know these algebraic processes.

Learners need opportunities to practise algebraic processes (Ayieko 2018, p. 32) and apply metacognitive strategies, for them to develop algebraic thinking.

## □ Reasoning forms

The fourth dimension of developing algebraic thinking is reasoning forms, comprising abductive, inductive and deductive reasoning (Pitta-Pantazi et al. 2019, p. 968). During the written task, learners needed a lot of motivation to do the questions in the reasoning forms section. Also, it seemed as if learners were more willing to reason in groups than in individual tasks. Learners are more eager to use metacognitive strategies such as asking questions, collaboration or group thinking and thinking aloud, than to use metacognitive strategies individually.

Abductive reasoning is based on individuals' prior knowledge and when a learner estimates or guesses, it is part of abductive reasoning (Kaplan et al. 2021, p. 817). A question in the written task to investigate abductive reasoning was as follows: 'State whether the statement is true or false:  $a \div b, = c$ , cannot be zero'. Nine participants stated that if  $c = 0$ , then the equation would be undefined. Most participants (A1, girl, Oct 2021; A3, boy, Oct 2021; B1, girl, Oct 2021; B2, boy, Oct 2021; B3, boy, Oct 2021; B5, girl, Oct 2021; C1, boy, Oct 2021; C2, girl, Oct 2021 and C3, girl, Oct 2021) had adequate abductive reasoning to develop algebraic thinking.

Inductive reasoning helps learners with the generalisation of patterns (Pitta-Pantazi et al. 2019, p. 981). A pattern was used in the written task to investigate inductive reasoning. First, they needed to extend the pattern in a table and secondly, they needed to determine the 100th term. Four participants (A1, A2, A3 and A4) were able to determine the 100th term from their informal methods without applying a formula. In other words, less than half of the participants had adequate inductive reasoning to develop algebraic thinking.

Deductive reasoning represents learners' ability to prove statements mathematically correct (Wasserman & Rossi 2015, p. 24). In the written task, learners were requested to write an algebraic expression to prove that angle  $BAC = 60^\circ$ . Four participants (A2, girl, Oct 2021; A3, boy, Oct 2021; B2, boy, Oct 2021 and B4, boy, Oct 2021) were able to prove it with a correct algebraic expression. Other participants (A1, girl, Oct 2021; A4, boy, Oct 2021; B1, girl, Oct 2021 and B3, boy, Oct 2021) proved the statement correctly without an algebraic expression. Learners need to develop deductive reasoning skills to be able to develop algebraic thinking. Reasoning forms (abductive, inductive and deductive) improve critical thinking (Chasanah 2019, p. 113), which is required for the development of

algebraic thinking. The four dimensions of developing algebraic thinking were investigated in the written task, and the obstacles that hindered the development of algebraic thinking were identified.

## □ Task-based interviews

Data from the written task emphasised the importance of mathematical language in the development of algebraic thinking. Metacognitive strategies are equally important to develop algebraic thinking. A metacognitive strategy wheel was developed to introduce metacognitive strategies to learners. This decagon has a metacognitive strategy in each wedge. The 10 simplified strategies are goal setting, keeping a journal, collaboration, modelling, planning, asking questions, know your challenges, know mathematics words, problem-solving strategies and think aloud (see Figure 9.2). During the task-based interviews, the participants each held their written task in their hands, while the researcher probed them on the metacognitive strategies that they had used to solve the problems.

No participant made use of a journal. Participant A4 (learner, boy, 20 Oct 2021) responded as follows: 'I don't keep a journal, but I write notes in my maths book about the steps, ... I use these notes to study for the exam'. During the task-based interviews, some participants explained that they made notes in their mathematics books for future reference. These sidenotes were made with colour pens or highlighters, but they were in an exercise book and not in a separate journal.

Only two participants did not prefer collaboration as a metacognitive strategy. One participant was an introvert and did not like collaboration with her peers, and the other participant who did not prefer collaboration as a metacognitive strategy was on the spectrum of autism. All the other participants were willing to help a peer or to ask a peer for help. Participant B2 (learner, boy, 20 Oct 2021) confirmed that: 'it always helps to ask a friend'.

Most of the participants (12) modelled a problem by drawing a table or picture to solve a mathematical problem. Patterns are part of algebra, and participants usually extend a pattern in a table format. During the task-based interviews, the researcher noticed that if a learner could model a problem, then they understood the problem, but if the learner did not understand the problem, then they were not able to model the problem. Participant C3 (learner, girl, 20 Oct 2021) said 'if you draw a picture or a table, you will understand better. You always need to think of a real-life example when you do maths'.

Planning as a metacognitive strategy was not used often by participants. However, participant A2 (learner, girl, 20 Oct 2021) said 'I first read through

the problem, then I plan the steps to solve it. When I have the answer, I check it by doing the opposite (inverse) operation'.

Participants ask their peers questions like 'Did you also get this solution?' and 'Why did you use the specific operation/why did you add instead of multiply?' In the task-based interviews, most learners stated that they found exponents and roots challenging. Participant A1 (learner, girl, 20 Oct 2021) expressed himself in this way: 'I ask my teacher if I don't understand how she got the answer ... I don't ask my friend, rather my mom or my teacher ... I will help my friends if they ask me'.

Others knew their challenges when they said they found geometry more difficult than algebra. Some participants stated in the task-based interviews that they could not answer a certain question because they did not know what the words 'commutative or distributive' meant. Participant B5 (learner, girl, 20 Oct 2021) was sure that 'I find it challenging to solve for  $x$ ' and Participant A4 (learner, boy, 20 Oct 2021) said 'I struggle with exponents and roots'.

The metacognitive strategy of knowing mathematics words helps learners to develop algebraic thinking. The response of participant B1 (learner, girl, 20 Oct 2021) was: 'I try to remember maths words, because maths is difficult if you don't know the words'. The researcher guided her learners to keep a 'maths dictionary', find the meaning of mathematics words in the glossary at the back of their textbook and write it in their 'maths dictionary'. Sometimes, it is possible to divide a word into syllables and find the meaning in the prefix or suffix – such as the prefix 'bi' means two, and 'tri' means three.

The researcher employed Polya's problem-solving model, namely: (1) understand the problem, (2) plan, (3) carry out the plan and (4) look back (Daulay & Ruhaimah 2019, p. 3). The problem-solving method the participants used started with reading the problem three times. If possible, they highlighted keywords such as all together, share, product or extend the pattern. Participant B5 (learner, girl, 20 Oct 2021) confirmed in this way: 'the first step to solve problems is to understand the problem'.

Thereafter, they did the calculation followed by verifying their answers by doing the inverse operation. Lastly, they read the question again to see if the answer was a possible solution to the problem. Think aloud is a metacognitive strategy that fits in with all the other metacognitive strategies. Participant B2 (learner, boy, 20 Oct 2021) commented: 'I speak to myself to test my mind'. If the participant responded incorrectly in the written task, the researcher asked the learner to read the question aloud in the task-based interview. The moment the participant read a question

aloud, they understood the question better. Participants were granted the opportunity to reflect and rethink. In other cases, participants asked themselves questions like 'Did I use the correct operation?' They understood better when they heard their own voices.

In the next section, a synthesis of the findings is provided.

## ■ Discussion

The first aim was to determine how the algebraic thinking of Grade 7 learners develops. Grade 7 learners' algebraic thinking develops in four dimensions, namely, general content strings, algebraic concepts, algebraic processes and reasoning forms (Chimoni et al. 2018, p. 966). The first dimension, algebraic concepts, involves general algorithms and functional thinking. Grade 7 learners were familiar with the first dimension of developing algebraic thinking, because it was taught in the Foundation Phase. The second phase, algebraic concepts, involves equality, properties of numbers, properties of operations, unknown values and variables and symbols (Pitta-Pantazi et al. 2020, p. 242). The third dimension that is needed for Grade 7 learners is algebraic processes, which involves observation, generalisation, presentation and testing for validation (Chimoni et al. 2018, p. 58). Reasoning forms is the fourth dimension needed to develop algebraic thinking and entails abductive, inductive and deductive reasoning forms (Pitta-Pantazi et al. 2020, p. 242).

The second aim was to investigate the role of mathematical language in the development of Grade 7 learners' algebraic thinking. Mathematical language plays a significant role in the development of algebraic thinking. Mathematical language needed for Grade 7 algebraic thinking is divided into subsections, such as symbols (Çelik 2020, p. 328). The researcher created the subsections of mathematical language: algebraic language, terms regarding operations and general mathematics words. It is important for mathematics teachers to teach mathematical language correctly to Grade 7 learners so that these learners can develop their algebraic thinking.

The third aim focused on metacognitive strategies that play a role in the development of Grade 7 learners' algebraic thinking. There are many suitable metacognitive strategies to develop algebraic thinking, but the researcher chose 10 strategies to demonstrate metacognitive strategies to her Grade 7 learners in a practical way (by means of the metacognitive strategy wheel illustrated in Figure 9.2). These strategies were keeping a journal, collaboration, modelling, planning, asking questions, knowing one's challenges, goal setting, knowing mathematics words, problem-solving strategies and thinking aloud (Du Toit & Kotze 2009, p. 59).

There was evidence of the use of metacognitive strategies in the algebraic task. On predicting whether they thought that they could solve the algebraic problem, those who thought that they could were successful. On the other hand, the learners who thought that they would not be able to solve the problem were unsuccessful. Furthermore, learners planned their problem-solving strategies by first reading the problem attentively and then selecting an operation to solve the problem. Most learners monitored their thinking and evaluated whether their solution was correct or not. One participant (B1) could explain her mistake: 'I did not draw correctly'. Learners also used modelling to solve problems  $-7 - 2 = -9$  for example, drawing a number line to solve the problem or drawing a table. Learners had to ensure that they understood the mathematical concepts before solving specific problems.

The primary aim of the algebraic task was to investigate the development of the participants' algebraic thinking. The four dimensions of the development of algebraic thinking were investigated, and findings showed that the participants' level of algebraic thinking was adequate at Grade 7 level. The secondary aim was to investigate metacognitive strategies. The conclusions from the data analysis of the algebraic task corresponded with those from the vocabulary test.

The purpose of the task-based interviews was to determine which metacognitive strategies play a role in the development of Grade 7 learners' algebraic thinking. Participants enjoyed using modelling to monitor their algebraic thinking. Participants in the A category (with strong mathematical language) did not find it necessary to draw pictures; instead, they used graphs and tables to model number patterns. Some participants used think aloud to monitor their algebraic thinking. Knowing mathematics words is a technique that participants mostly use for monitoring.

Think aloud is the technique that most participants used to assess their algebraic thinking. The researcher asked a question to examine participants' ability to evaluate their work. The question was how sure the participant was that their feedback on a question in the algebraic task was correct. The problem focused on the sum of the interior angles of an equilateral triangle. Most participants confidently answered that they were correct because  $180^\circ \div 3 = 60^\circ$ . Another participant explained 'I measured it'. This is not a reliable answer as diagrams are often not drawn to scale. In the word sums, participants used the inverse operation and the isolation method to monitor their thinking.

From the data, it was evident that learners were able to use metacognitive strategies during problem-solving and that they could think algebraically at the appropriate and required level of thinking in Grade 7.

## ■ Conclusion

This chapter aimed to shed light on the role of metacognitive strategies and mathematical language in the development of learners' algebraic thinking. Findings showed that a well-developed mathematics vocabulary contributes to the development of algebraic thinking. In addition, the use of suitable metacognitive strategies complements the development of algebraic thinking and contributes to SDL characteristics. The metacognitive strategy wheel is regarded as a contribution to schoolteachers to assist them in teaching metacognitive strategies to learners.

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# Proposing a model for analysing the relationship between metacognitive awareness and worldview as mediating constructs of self-directed learning<sup>6</sup>

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6. This chapter represents a substantial reworking (more than 50%) of Van der Westhuizen, CG, 2023, Dissertation accepted for the degree Master Education in Curriculum Studies, entitled, 'Intermediate phase teachers' metacognitive awareness and worldviews for the process of self-directed learning in private school settings', with Dr Divan Jagals (supervisor) and Dr Marisa Verster (co-supervisor), North-West University, <http://hdl.handle.net/10394/42214>.

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## ■ Abstract

This chapter reports on an investigation into the relationship – mediated by self-directed learning (SDL) domains – between in-service teachers' worldview and metacognitive awareness. The research method adopts a quantitative approach within a postpositivist paradigm to empirically discover the connection between metacognitive awareness and worldview in promoting SDL. This study focused on a representative sample of 142 responders from a South African private school group. The research tools included (1) worldview test, (2) metacognitive awareness inventory and (3) SDL Readiness Scale – of which descriptive and inferential statistics were calculated. Based on the calculations, structural equation modelling suggests four models, aligned with the hypotheses for this study. Model 1 shows a continuous interaction between metacognitive knowledge (what technique do I need to do this task?) and metacognitive regulation (watching myself) to inspire someone to take initiative and become more self-directed. The link between the visible realm of SDL and the integrated worldview is presented in Model 2. Model 3 proposes that the growth of SDL is specifically aided by metacognitive knowledge. Model 4 suggests that the development of SDL is supported by metacognitive knowledge and an integrated worldview. The authors aimed to ascertain the model's substantial fit in gauging the link between metacognitive awareness and worldview while considering the mediating role of visible and affective domains in SDL. They sought to explore whether teachers' metacognitive awareness directly impacts their worldview and their SDL, alongside investigating whether teachers' worldview directly influences their SDL.

## ■ Introduction

The expression 'worldview' originated linguistically from the German word 'Weltanschauung', which denotes a particular perspective or view on the world (Naugle 2002, p. 17). According to Miller and West (1993, pp. 3–19), there is also another meaning of the term 'worldview' that describes a collection of interrelated customs (like worldview features) and ideas about one's own world. According to earlier studies, many researchers have attempted to define their worldview and described how it influences education and psychology (Koltko-Rivera 2004, p. 303). A more contemporary meaning of the word 'worldview' demonstrates notable correlations between an individual's worldview and their opinions (e.g. whether they choose to attend a public or private school) and their behaviour (e.g. what teaching strategy to use) (De Witt et al. 2016). As a result, the teaching environment and the way they perceive their classroom experiences, mould and impact instructors' worldviews. For this study, a

worldview is conceptualised based on meaning-making – that is, it develops during a teacher’s lifetime from the point of having a perception to providing a perspective as a frame of reference that directs moral decisions, decision-making, thinking evaluation and self-perception of reality. The worldview aspects, therefore, serve as those fundamental categories which teachers can reflect on to help shape their own teaching practices and beliefs.

In order to develop the capacity for teaching and learning in the 21st century, the worldwide education community has been extensively pushed in the last 20 years to implement innovative learning initiatives. One major topic includes the motivation for novel models of learning (Chahine 2023). Amidst this need, Pretorius and Lephallala (2011, p. 486) refer to the education crisis faced in South Africa as ‘problematic’. The improvements made to date remain inadequate to the country’s educational needs, and the education system is still failing learners and teachers by any neutral standards. The problem is made worse by a lack of infrastructure and resources for education, poor leadership and a teacher shortage (Macha & Kadakia 2017, p. 370). South Africa has therefore consistently received the lowest ranking in many Progress in International Reading Literacy Studies (PIRLS) surveys (Mullis et al. 2012). It is no wonder that these unceasing challenges in the public education system increase the demand for independent schools and present an opportunity to establish more private schools. It is often argued (Mupunga 2019) that such educational institutions may provide better quality education opportunities for learners, suggesting a globalised marketisation strategy with the promise of a more competently managed educational counterpart.

Within South Africa’s education crisis, there seems to be an emergence of two seemingly integrated systems of ontological boundaries – a term borrowed from Larsen (2006). The one refers to the tangible manifestation of the rising need to create lifelong, creative, problem-solving and self-directed learners (Van Aswegen, Swart & Oswald 2019, p. 3). The other refers to the condition of this manifestation, that is, the contextual stakeholders’ involvement is considered. These circumstances include curricular discourses on globalisation and marketisation, neo-liberalism, curriculum instrumentalism and *Ubuntu* currere. They also involve conflicts in educational needs and policy, including theoretical traditions and difficulties with epistemological access.

The literature on educational research considers teachers’ worldviews, beliefs and experiences in the classroom and reports on how these individual (self-) epistemologies connect to their instruction (Solis 2015, p. 246). Pedro and Van der Merwe (2020, p. 19) and Jagals and Van der Walt (2018, p. 5) contend that educators can cultivate a favourable attitude about these individual (self-) epistemologies and their personal beliefs can

form the content of their worldviews. This transition between the tangible and conditional manifestations within the world of education is both static and dynamic in nature (Larsen 2006). Take, for example, a case where a teacher is given a curriculum and qualified (with) models of learning to teach that content in their classes. These teachers stay within a static relationship with their educational life world and portray what Knowles (1975, p. 96) referred to as the Newtonian conception (i.e. fixed intelligence, developmental order, fixed human potential, telephone switchboard brain and inactivity). Alternatively, if the same teacher is offered control to shape and reshape their teaching practice, their relationship with the educational world will become more dynamic as they become more self-directed. Knowles (1975, p. 96), founder of the term 'self-directed learning', explains this as the Einsteinian conception, that intelligence is modifiable, development is modifiable – a computer brain where learning is a continuous activity. One suggestion is that habitually reflecting on one's thoughts and actions can serve as a form of metacognitive awareness, a key instigator to empower the modelling and development of SDL, given the increasing body of research supporting the need for more reflective teacher practice (Bower 2003; Joshi 2023).

There remains, however, the question: What new model can help us comprehend how metacognitive awareness and worldview relate to each other in order to support SDL?

Traditions around conventional education (research) have not adequately acknowledged or addressed the link between metacognitive awareness and worldview, including teacher education programmes (Li 2016; Russell & Martin 2017, p. 27). Studies on the promotion of metacognitive awareness (Jagals & Van der Walt 2016, p. 156) and the development of teachers' worldviews (Chan & Wong 2014, p. 251; Solis 2015, p. 247) towards the promotion of SDL (Du Toit-Brits 2019, p. 2), have yielded only a limited view to access such an understanding. To encourage SDL, a deeper comprehension of the connection between metacognitive awareness and worldview is still required. This article, consequently, serves to narrow the existing scarcity of literature in this field. The remainder of this chapter is structured as follows: Initially, a conceptual-theoretical framework is presented as a proposition model, to provide a model for comprehending the conceptual overlaps between metacognitive awareness, worldview and SDL, based on a survey of the literature and underlying hypotheses. This is followed by a report on an empirical investigation in the form of a quantitative study that generated the data used for testing and refining the proposed model. The results and findings are then presented and interpreted. The chapter ends with a discussion of the models and reflects on opportunities for further research.

The following hypotheses are intended:

- The metacognitive awareness of teachers has a direct effect on their SDL.
- Teachers' worldview has a direct effect on their SDL.
- The visual and emotional dimensions of SDL mediate the link between metacognitive awareness and worldview, and the suggested model shows a strong match in this regard.
- The metacognitive awareness of teachers has a direct effect on their worldview.

## ■ Conceptual-theoretical framework

De Witt et al. (2016, p. 102) explain that the ideal-typical scheme for organising worldviews employs worldview features to distinguish between integrative, postmodern, contemporary and traditional worldviews in the West. A worldview consists of several elements such as anthropology, social vision, axiology, ontology and epistemology. The authors used egalitarian-collectivist worldviews rather than individualistic-hierarchical ones to categorise these worldview types using a core binary method. These worldview components serve as a theoretical model, arranged in the conceptual framework that follows in accordance with how well they theoretically correspond with features of metacognitive awareness for SDL.

## ■ Worldview in education

For the purpose of this study, and in line with De Witt et al. (2016, p. 106), we considered the individual worldviews as a collection of five worldview components, namely 'Ontology, Epistemology, Axiology, Anthropology and Societal Vision' (De Witt et al. 2016, p. 102). Beliefs concerning the nature of one's universe, existence and reality are referred to as ontologies. The philosophy of knowledge, or the views that people have about knowing and knowledge, is known as epistemology. A person's axiology is their set of values (e.g. what is good?). Human behaviour is the focus of anthropology, and society's collective perception of social behaviour is known as societal vision. The findings of studies in developmental psychology, philosophy and sociology have also hinted at the existence of these worldview groups (De Witt 2013). Researchers (e.g. Özgen et al. 2019, p. 144) examined teacher-and-learner attitudes regarding awareness and understanding, and the impact thereof on teaching and learning. Table 10.1 compares the attributes of each worldview with its underlying worldview components.

**TABLE 10.1:** Worldview attributes within education.

<b>Worldview component</b>	<b>Traditionalist</b>	<b>Modernist</b>	<b>Postmodernist</b>	<b>Integrative</b>
<p><b>Ontology</b></p> <p>The nature of reality</p>	<p>Reality is singular and superior</p> <p>The material world is where I look for knowledge</p> <p>What I see is what it is, for example, a classroom with desks, chairs, a blackboard and textbooks make up my educational reality</p> <p>After the desired behaviour has been expressed, set up the right setting and supply the right stimuli</p>	<p>Rejects realism (Graff 1973, p. 383)</p> <p>Reality is inherent</p> <p>More than one reality can exist</p>	<p>Reality is pluralistic and socially structured (De Witt 2013, p. 96)</p> <p>There is no historical or scientific truth, nor is there an objective reality</p>	<p>Reality is not static and inflexible; rather, it is an integrated totality (De Witt 2013, p. 86)</p>
<p><b>Epistemology</b></p> <p>A perspective on how knowledge of reality can come about</p>	<p>Knowledge is treated as truth (De Witt 2013, p. 76)</p> <p>Learners are seen as blank slates</p> <p>Learning occurs in the form of memorisation and regurgitation</p> <p>Knowledge construction is deductive</p>	<p>Truth is objective</p> <p>Knowledge is still treated as truth</p> <p>Learners have prior knowledge and continue to build their scheme (Ackerman 2003, p. 345)</p> <p>Inductive reasoning</p>	<p>Relativism and scepticism</p> <p>Deconstruction of knowledge (Duigan 2019)</p> <p>Divergent thinking: coming up with and exploring new ideas</p>	<p>Problem-based learning</p> <p>Divergent thinking</p>
<p><b>Axiology</b></p> <p>What constitutes a decent life in terms of morality, standard of living, and aesthetic and ethical principles</p>	<p>Emphasis on traditional values, tradition and family (Ackerman 2003, p. 346)</p> <p>Critical thinking and reflection discouraged</p> <p>Individual creativity suppressed</p>	<p>Independent individuality (Ilechukwu 2016)</p> <p>Focus on an individual's cognitive and affective, ambition needs</p>	<p>Self-expression, unique individuality</p> <p>Learners are social, cultural beings of a community (Williams 2017, p. 7)</p> <p>Reject imposed belief structures</p> <p>Value, reality and knowledge are created in a community through common discourses</p>	<p>Self-expression</p> <p>Doing something for the greater good</p> <p>Serve society</p> <p>Discover your purpose</p>

Table 10.1 continues on the next page→

**TABLE 10.1 (cont.):** Worldview attributes within education.

<b>Worldview component</b>	<b>Traditionalist</b>	<b>Modernist</b>	<b>Postmodernist</b>	<b>Integrative</b>
<b>Anthropology</b> A viewpoint on the nature of the human person and what his or her place and function in the cosmos are	Learning is controlled by an authoritative figure  Teacher-centred approach  The teacher transfers and prescribes knowledge  Use operant conditioning to alter desirable behaviours and abilities after modelling them to the desired standard  Dominant learning theory of behaviourism	Learning is facilitated by an authority figure  Learner voices used to validate the curriculum  Pursue independence (De Witt 2013)  Dominant learning theory: constructivism	Human behaviour is socially constructed  Enable students to create information that they can access for the rest of their lives  Pursue voices that are marginalised  Learner-centred	Teacher and learners learn together  Assist the learner to connect various networks of knowers, inquires and knowledge basis  Enable students to create information that they can access for the rest of their lives
<b>Societal vision</b> How a society should be organised and how societal problems and issues should be addressed	Traditional ways of doing  Building a community  Societal values are emphasised (De Witt 2013; Kane 2019)	More mechanistic modes of doing and thinking than purely traditional methods of doing and thinking  Awareness of scientific advancements to help solve problems (De Witt 2013)	The creative entrepreneurial society  Learning is a process of forming new relationships with the community  Question status quo  Incorporate race, culture, language, religion, viewpoint and social class	Thoughtful and deliberate personal development  Personal growth that will allow for the blending of many societal viewpoints and interests  Together, educators and students strive towards an integrated society. Social change is possibly empowering individuals (Biesta 2020, p. 40)

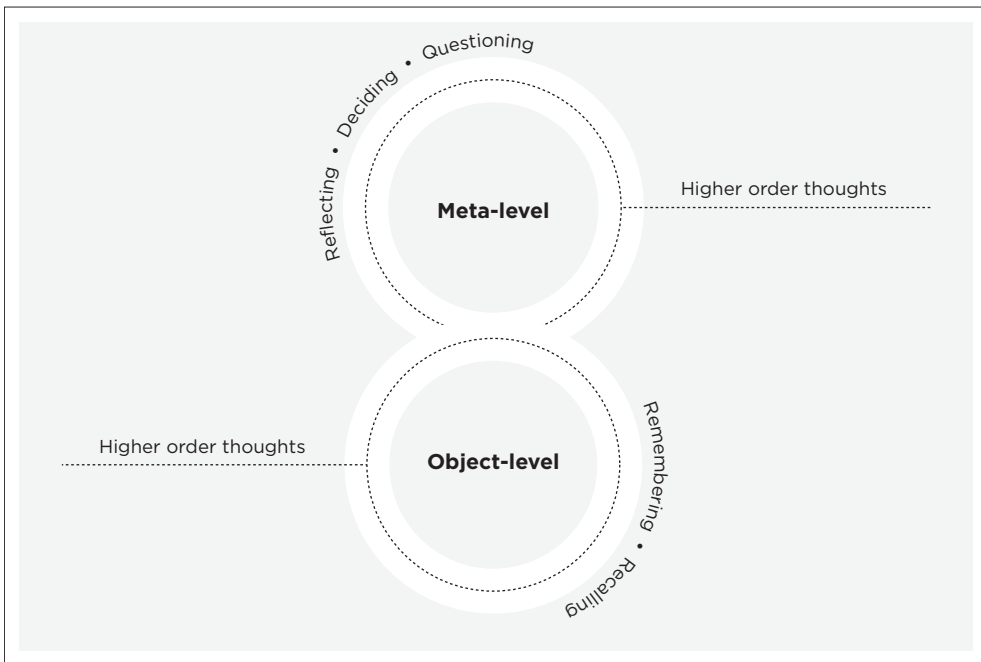
Source: Authors' own conceptualisation of the work of De Witt (2013).

## ■ The process of facilitating metacognitive awareness

One may argue that the preceding definition of worldview can be used as an epistemic instrument to support metacognitive awareness (Funk 2001; Jagals & Van der Walt 2018, p. 6). The word 'metacognition' was first used in the late 1970s by Flavell (1979, p. 906), who defined it as a person's reasoning about their own mind or cognitive processes. Nelson and Narens (1990) portray this process as follows: On the object level, remembering

and recalling lower-order thoughts can be considered cognitive processes. The monitoring of these thoughts and the questions, reflections and decisions that ensemble the higher-order thoughts are considered metacognitive processes on the meta-level. Consider a teacher's decision to engage in the task of assessment. On the object level, the teacher will think, experience some form of motivation or affect and execute a plan to implement. On the meta-level, the teacher will gather and organise information, reorganise knowledge and reflect implicitly as well as perceptually on the outcome of the lesson. This process (adopted by Jagals [2015]) also acknowledges the role that environmental conditions can play (considering the influence of ontological boundaries) (Funk 2001). Figure 10.1 demonstrates how this process can occur.

Metacognitive processes can be integrated by monitoring and control during this process. If a teacher has prior experience summarising texts, they can use it to their advantage. After that, they can monitor and control the process by posing queries like 'Do I comprehend what I have read?' and 'Does the summary make sense?'. Therefore, 'monitoring' - a process that involves asking questions or underlining keywords - provides the meta-level with information about how the object level functions, while the metacognitive process of control aids the meta-level in controlling



Source: Adapted from Nelson & Narens 1990.

**FIGURE 10.1:** Cognition and metacognition on the object level and the meta-level.

the management of object-level procedures in order to accomplish a specific objective (Koriat 2019, p. 465). Because they govern cognitive methods, monitoring and control are therefore two higher-order metacognitive processes.

Planning, monitoring and assessing are examples of meta-level cognitive processes, whereas remembering, recalling, labelling, listing, perceiving and comprehending are examples of object-level cognitive processes. Because higher-order strategies represent thinking that goes beyond perception, comprehension and memory, they govern cognitive methods. The term 'metacognition' may therefore be used to describe a variety of epistemic procedures (techniques) that a person uses while processing information about information or considering ideas, deeds and behaviours (Papleontiou-Louca 2003, p. 21).

According to the literature, metacognition has become more prevalent in studies on education in the last 10 years. According to research by Chekwa et al. (2015, p. 109), metacognition is necessary for successful learning. This supports knowledge and control over how educators conceptualise their ideas, which informs their instructional strategies. According to Smith, Black and Hooper (2020, p. 626), suitable tactics including asking, drawing conclusions, activating past knowledge, synthesising, self-monitoring and reflection may be used to teach and nurture metacognitive awareness. Using this strategy can enable educators to better navigate the issue and choose the most effective teaching strategies.

## ■ The promotion of self-directed learning

Malcolm Knowles pioneered SDL in education contexts and the crucial role that adult educators have in assisting students in learning and understanding rather than just imparting knowledge (Smith 2002). Although there are many definitions for the term 'self-directed learning', Xu and Ko's (2019, p. 107) definition suggests that SDL is the process by which a teacher exhibits independence and control when guiding, supervising and controlling actions to achieve learning objectives. According to earlier studies, SDL is an intellectual and rational process in which teachers consciously choose their goals for both teaching and learning, acting as change agents for their students' education in the process (Cazan & Schiopca 2014, p. 640).

Current definitions of SDL consider earlier definitions while also acknowledging and including certain components that influence the process of SDL. These components include the educational environment and subject content, as well as the instructors' self-concept, pertinent study abilities, prior experiences, cultural background and worldview (Du Toit-Brits 2019, p. 3). In addition to thinking about the abilities necessary to become an effective

self-directed teacher, educators who model SDL skills also frequently reflect on their epistemological views (Bhat, Rajashekar & Kamath 2007, p. 2).

## ■ Transforming worldviews through metacognitive awareness

Metacognition includes reflection on many aspects of one's self and life (Four Arrows 2016, p. 262). Worldview is one such element that plays a major role 'in addressing our highly complex, multifaceted, interwoven, planetary sustainability issues' (De Witt 2013, p. 3). A worldview is often reflected upon by comparing it (the dominant view for example...) to one that is significantly different (the opposing view for example...) (Four Arrows 2016, p. 262). As an alternative, focus can be placed on comprehending these two points of view as merely two operational, historically observable viewpoints (Four Arrows 2016, p. 262). As a result, an increasing number of people are starting to recognise the benefits of a worldview that influences how people behave (Narvaez 2013). Tarnas (2007) writes:

Worldviews create worlds ... what sets the modern worldview apart is its fundamental tendency to assert and experience a radical separation between subject and object, a distinct division between the human self and the encompassing world. This perspective can be contrasted with what has come to be called the primal worldview, characteristic of traditional indigenous cultures. (p. 16)

In the following list of worldview components identified by Four Arrows (2016, p. 263), all seven of these worldview characteristics are in some form or another evident in our education system.

1. 'Life and acceptance of its mysteries define "Indigenous religion".'
2. Everything is connected and equal in significance and in deserving respect.
3. Ceremony is vital for internalising Nature's wisdom.
4. Place and its inhabitants are sacred.
5. Complementarity describes Nature and is essential for a balanced life.
6. Generosity and courage are pre-eminent virtues observable in Nature.
7. The highest authority comes from honest reflection on lived experience'.

'Worldview, encourages metacognition and increases the self-awareness', according to Tardiff (2022). In this view, feedback from on-site real-time questionnaires like <https://wvtest.com/> is used to develop learning journeys that invite people to explore 'the big questions'; converse with those who think differently; and consider their opinions in a larger context of planetary crisis and opportunity. These journeys empower people to expand mindsets, collaborate constructively and initiate creative change in a world in crisis (accessed: 8 June 2023). The transformational learning theory validates this process's methods (Mezirow 1978).

Teachers can use the transformational learning theory to evaluate new material by comparing it to prior knowledge or experiences, which can help them critically reflect on their own worldview (Howie & Bagnall 2013, p. 816). Teachers who critically reflect on what they know or believe they know to make room for new discoveries are better able to engage in metacognitive awareness. Only then can a teacher decide how to guide behaviour after learning about personal assumptions, judgements and beliefs. As a result, critical reflection shapes the epistemological presumptions that guide educators' attitudes, viewpoints, habits of thought and pedagogical strategies (Fazio-Griffith & Ballard 2016, p. 225). According to Van Aswegen et al. (2019, pp. 1-12), doing so facilitates the acquisition of new knowledge and helps one become conscious of their own thoughts while they are learning and making meaning.

## ■ **Transcending metacognitive awareness into self-directed learning**

The background provided above, suggests that, in terms of the work of teaching, it remains the teacher's responsibility (and not some or other group's or collective's responsibility) to regulate SDL. Thus far it has become evident that such a transformation (be it on a personal level) stems from the development of a metacognitive process of regulating one's knowledge and worldview to become metacognitively aware.

Whether the focus is on changing one's perspective or going beyond metacognitive awareness, SDL necessitates, in terms of psychological well-being, the self-transcendence hypothesis is described by Maslow's (1943) hierarchy of needs (Koltko-Rivera 2006, p. 309). Maslow (1971) added self-transcendence to his theory, which is where the phrase 'self-transcendence' originated.

The word transcendence denotes ascending to a higher level or transcending something. By concentrating on a purpose greater than oneself, one can transcend their typical constraints, beliefs and ideas and achieve transcendence. This has consequences for their behaviour and thinking (Messerly 2017). Maslow's notion of self-transcendence essentially captures the link between metacognitive awareness and SDL. People (teachers in this case) may transcend themselves to incorporate and accommodate alternative ways of knowing, being and teaching as they grow in metacognitive awareness of oneself, which encompasses thoughts, beliefs, behaviour and worldview. As these are metacognitive abilities required to be an effective teacher, educators who are interested in self-transcendence may want to consider their views about how they organise, oversee and assess themselves. As a result of this literature review, Table 10.2 can be used as a summative profile of the concepts and their theoretical relationship with one another.

**TABLE 10.2:** Profile of the conceptual framework.

<b>Subscale</b>	<b>Metacognition</b>	<b>Self-directed learning</b>	<b>Traditionalist worldview</b>	<b>Modernist worldview</b>	<b>Postmodernist worldview</b>	<b>Integrative worldview</b>
<b>Self-awareness</b>	Understanding one's own thoughts and cognitive processes including strengths and weaknesses	Awareness of one's learning preferences, strengths and weaknesses in learning	Emphasises adherence to established norms, values and traditions	Emphasises rationality, scientific progress and objective knowledge	Challenges universal truths and hierarchical structures advocate for diverse perspectives	Integrates diverse perspectives, values and multiple ways of knowing
<b>Monitoring</b>	Observing and assessing cognitive processes during learning or problem-solving tasks	Monitoring one's own learning progress, understanding when to adjust strategies	Values stability and consistency in learning processes	Values systematic approaches, efficiency and progress through innovation	Questions authority and meta-narratives, favours plurality of perspectives and interpretations	Seeks a balance between tradition and innovation, acknowledges complexity and interconnectedness
<b>Planning</b>	Strategising and setting goals for cognitive tasks, including selecting appropriate strategies	Planning and setting objectives for learning goals, selecting resources and organising study plans	Prefers structured and predetermined learning objectives	Emphasises goal-oriented, structured learning with clear steps for achievement	Embraces fluidity and adaptability in learning approaches	Encourages flexible and adaptive approaches to learning
<b>Evaluation</b>	Assessing the effectiveness of strategies used and the outcomes achieved in a task	Evaluating learning outcomes, reflecting on the effectiveness of methods used and making improvements	Emphasises testing and evaluation to measure learning outcomes and success	Values assessment based on objective criteria, emphasising measurable outcomes	Questions fixed assessments, promotes diverse forms of assessment that respect individual contexts	Promotes reflective evaluation, considering multiple perspectives and contexts
<b>Regulation</b>	Controlling and adjusting cognitive processes to enhance learning or performance	Regulating learning by managing time, motivation and resources to achieve learning goals	Favours adherence to established rules and guidelines	Emphasises structured learning environments, fostering discipline and structure	Embraces autonomy and self-regulation in learning, allowing for individualised approaches	Encourages self-regulation while acknowledging the influence of external factors on learning
<b>Reflection</b>	Reviewing and analysing past experiences to gain insights and improve future performance	Reflecting on learning experiences, identifying areas for growth and adapting learning strategies	Values adherence to tradition and past practices, preserving established knowledge	Values critical thinking and reflection on learning experiences for continuous improvement	Questions absolute truths, encourages critical reflection and exploration of diverse perspectives	Encourages critical reflection and learning through diverse perspectives and experiences

Source: Authors' own conceptualisation.

Each worldview offers a distinct perspective on learning, knowledge and personal development, influencing how individuals perceive and engage with metacognition and SDL. These views highlight different values, priorities and approaches to learning and personal growth.

## ■ Empirical design of the study

The current study is descriptive and uses structural equation modelling to demonstrate a correlational pattern. The goal of this kind of study is to identify a likely association between the variables under investigation (in this case metacognitive awareness and worldview) by considering the role of mediating variables (such as the dimensions of SDL) to present this relationship in the form of a model. In the current study, respondents represented both male and female teachers from a private school group in South Africa, particularly intermediate-phase Afrikaans and English language teachers. The population counts about 1000 teachers across the country. The purposive availability sample produced 142 complete responses to items in three online research instruments.

## ■ Research tools

**The worldview test:** This online test was created by De Witt et al. (2016) as a tool to map the main worldviews. Firstly, 17 items were identified and selected from De Witt et al. (2016, p. 107) and prepared in an online data collection tool which delivered the data in an Excel format, with permission from the authors. The questionnaire includes five factors about worldview (determined as the five worldview aspects) and includes ontology, epistemology, axiology, anthropology and societal vision. Secondly, these aspects were considered as subscales in the questionnaire and arranged according to responses on a Likert-type scale (0 = did not choose; -1 = least agree; and 1 = most agree).

**The metacognitive awareness inventory:** This inventory was developed by Balcikanli (2011, p. 1330) and focused mainly on teachers' metacognitive awareness. It consisted of 24 items on a five-point Likert scale - 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; and 5 = strongly agree. The questionnaire measures responses to statements about respondents' metacognitive knowledge (incl. declarative, procedural & conditional) and metacognitive regulation (incl. planning, monitoring & evaluation).

The SDL scale: This scale was developed by Khiat (2015), mostly used in education settings and measured on a Likert-type scale - 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree - and consisted of 10 subscales:

1. 'Assignment management
2. Online learning proficiency
3. Stress Management
4. Technical proficiency
5. Procrastination management
6. Online discussion proficiency
7. Seminar learning proficiency
8. Comprehension competence
9. Examination management
10. Time management'

## ■ Ethical considerations

This study was approved by the North-West University's Faculty of Education Research Ethics Committee with study approval number NWU-01264-20-A2. The North-West University classified this study as low-risk for the following reasons: (1) there was a valid research design in place; (2) privacy and confidentiality were applied; (3) there was no conflict of interest; (4) there was no direct or indirect harm to any of the participants; (5) no participants came face to face with the researcher, thus Covid-19 procedures did not apply; and (6) there was no handling of paper, as recruitment was done by e-mail.

## ■ Results

Descriptive and inferential statistics were employed in this study's data analysis. In descriptive statistics, central indices like frequency, mean and standard deviation have been employed. By considering the mediating factors of SDL, structural equation modelling has been applied in inferential statistics to create a model of the link between metacognitive awareness and worldview.

Cronbach's alpha has a value between 0 and 1. Greater internal consistency between the elements is indicated by higher values. A number of 0.5 or above is usually regarded as satisfactory. Path analysis, confirmatory factor analysis, measurement model analysis and structural model analysis have all been used to evaluate the major and minor hypotheses because a full model of structural equation reflects the mixing of the path diagram and the confirmatory factor analysis.

**TABLE 10.3:** Frequency of the sample.

Language of instruction	Frequency	Respondents per province	Frequency	Grades taught in the intermediate phase	Frequency
Afrikaans	30	Western Cape	26	Grade 4 only	23
English	112	Northern Cape	3	Grade 5 only	8
-	-	Eastern Cape	1	Grade 6 only	14
-	-	Gauteng	67	Grade 4, 5 and 6	97
-	-	North-West	4	-	-
-	-	Limpopo	1	-	-
-	-	Mpumalanga	14	-	-
-	-	Free State	4	-	-
-	-	KwaZulu-Natal	22	-	-
-	<b>Total: 142</b>	-	<b>Total: 142</b>	-	<b>Total: 142</b>

Source: Van der Westhuizen 2023, p. 76.

Based on Table 10.3, the highest frequencies are for the English teachers ( $n = 112$ ) and for the Gauteng province ( $n = 67$ ).

## ■ The two domains of self-directed learning

The initial calculations of Cronbach's alpha values for all 10 SDL items were  $\alpha = 0.195$ , indicating a low mean inter-item correlation of 0.015. Consequently, a few elements were eliminated and recalculated, leading to the factorisation of SDL into two sub-variables: SDL 1 ( $\alpha = 0.765$ ) and SDL 2 ( $\alpha = 0.637$ ). Self-directed learning 1 was renamed as the 'visible domain' and SDL 2 as the 'affective domain' of SDL for the purposes of the study.

Two components of SDL were created once the dependability was determined. Self-directed learning 1, generally referred to as the SDL visible domain, comprised the subsequent subscales: 'online learning proficiency, seminar learning proficiency, technical proficiency, procrastination management, online discussion proficiency and comprehension competence'. The following subscales were part of SDL 2, sometimes referred to as the affective domain of SDL: 'assignment management, seminar learning proficiency, examination management, and time management'. The visible domain appears to include more visible elements, such as a teacher's deliberate choice to put off tasks, their level of technical proficiency when using basic computer programmes and their decision to participate in online discussions, even though all 10 qualities of SDL were evident. The four subscales of the emotional domain contribute to an individual's emotive beliefs and locus of control over a task, even if the affective domain also contains observable factors. One may be able to

schedule classes, gain new information and skills, manage their time and have control over how assignments are handled.

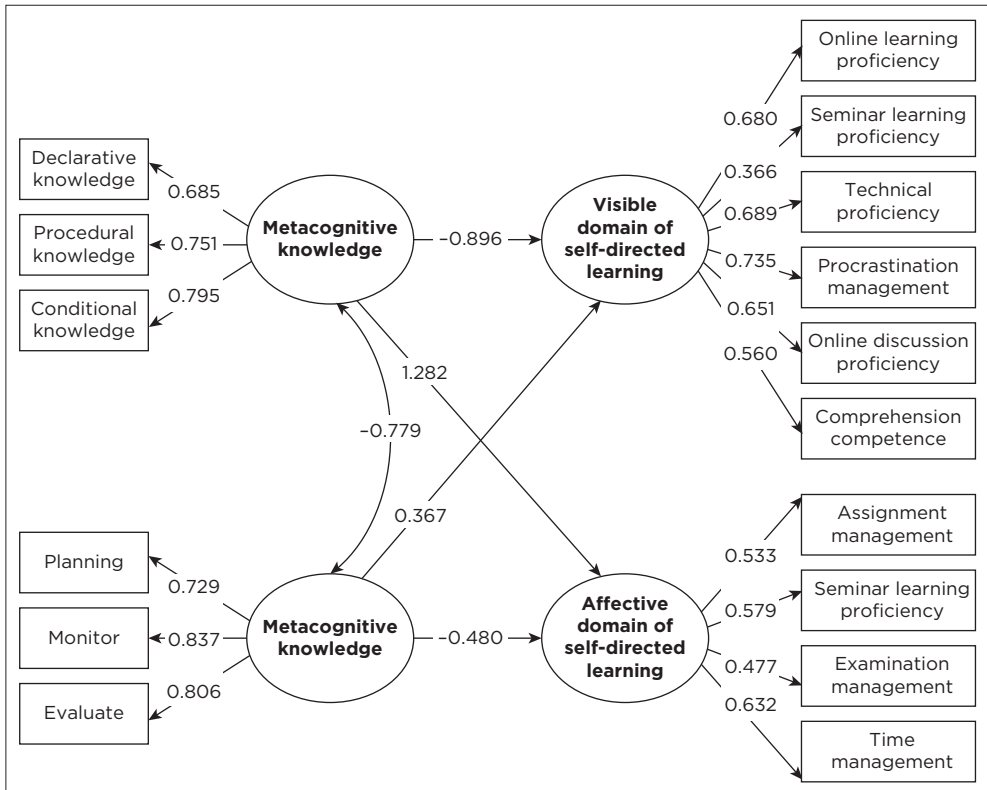
The four models describe how the three primary concepts relate to one another and are presented in the section that follows. Hancock and Mueller (2010) state that the quality of fit of the model is assessed using the chi-square test. Mueller (1996) suggests dividing the statistic produced by the chi-square test by the degrees of freedom (CMIN/DF), resulting in a value of 4.463 (CMIN/DF). This value is considered to be well-fitting to the model. Additionally, according to Mueller (1996), a comparative fit index with values higher than 0.09 indicates a strong overall match (CFI). With a 90% confidence interval [CI] of [0.08; 0.10], the two-factor model's relative acceptability was indicated by its CFI of 0.87 and its root mean square error of approximation (RMSEA) of 0.09. According to Blunch, models with RMSEA values of 0.10 or higher. Models with RMSEA values of 0.10 or higher, according to Blunch (2008), should not be accepted.

## ■ **Model 1: The metacognitive awareness of teachers has a direct effect on their self-directed learning**

The assessment paradigm for metacognitive awareness of SDL is displayed in Figure 10.2. Twenty variances, 38 regression weights, one covariance, 20 means and 18 intercepts total 97 free parameters in the parameter summary for Model 1. For metacognitive awareness and SDL, all  $p$ -values are less than 0.05, suggesting statistical significance.

The structural model indicates that both visual and emotional dimensions of SDL connect with all subscales of metacognitive knowledge and metacognitive control at the  $p < 0.05$  level. Self-directed learning is defined as a transitional process that incorporates an instructor's capacity (and desire) to learn on their own as they deliberate, consider and then choose which precise steps to do to accomplish certain learning objectives. Although these behaviours may be practically apparent, they are controlled by an individual's degree of emotional beliefs (motivation and attitude) and metacognitive knowledge (understanding of a task). Metacognitive awareness is the combination of metacognitive knowledge and metacognitive regulation. It describes how a teacher comprehends a task, knows about a task and knows how to check oneself while the work is being completed.

Metacognitive information (what strategy do I need to accomplish this task?) and metacognitive regulation (watching myself) constantly interact in an imperceptible way to encourage an individual to act and become



Source: Adapted from Van der Westhuizen 2023, p. 100.

**FIGURE 10.2:** Metacognitive awareness of self-directed learning.

more self-directed. The unobserved variables of knowledge and regulation have a covariance and correlation, as shown in Figure 10.2. (0.779). CMIN/DF (1.687), CFI (0.913) and RMSEA (0.055) with a 90% CI [0.040; 0.069] all indicate that Model 1 is a strong match.

## ■ Model 2: The metacognitive awareness of teachers has a direct effect on their worldview

A total of 88 free parameters, or 16 variances, 34 regression weights, 6 covariances, 16 means and 16 intercepts make up the parameter summary for Model 2. The standardised regression estimates and  $p$ -values for the structural model pertaining to the association between SDL and various worldviews are presented in Table 10.4. According to the structural model of worldview and SDL, the only worldview that significantly correlates with the visual domain ( $p = 0.000$ ) and the emotional domain ( $p = 0.052$ ) of

**TABLE 10.4:** Mean, Cronbach’s alpha and standard deviation of research variables.

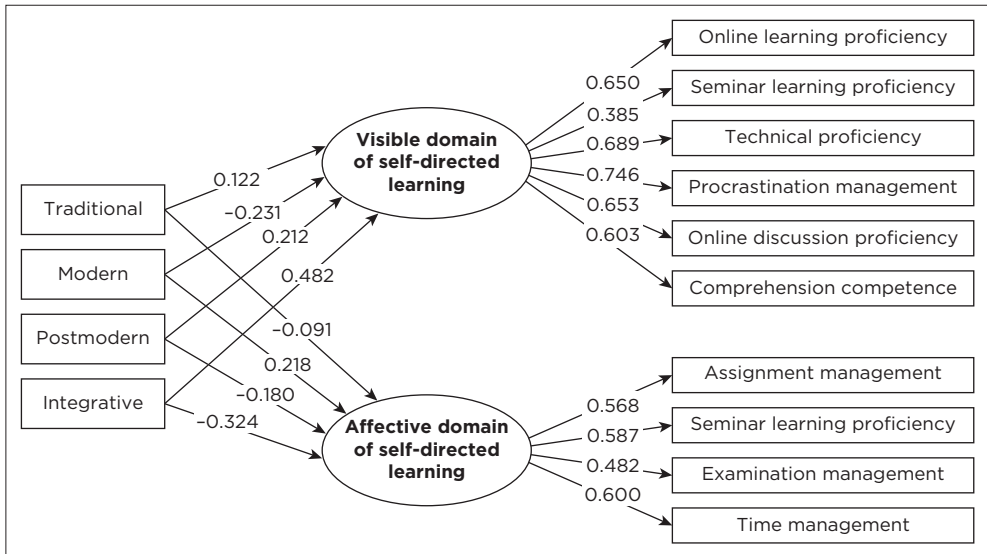
Statistical index variable	Mean	Cronbach’s alpha	Standard deviation
<b>Self-directed learning scale</b>			
Assignment management (AM)	4.28	0.65	0.58
Online learning proficiency (OLP)	1.93	0.71	0.75
Stress management (SM)	2.87	0.51	0.94
Technical proficiency (TP)	1.65	0.83	0.77
Procrastination management (PM)	1.95	0.60	0.66
Online discussion proficiency (ODP)	1.83	0.74	0.69
Seminar learning proficiency (SLP)	3.78	0.73	0.68
Comprehension competence (CC)	2.06	0.69	0.73
Examination management (EM)	4.18	0.73	0.65
Time management (TM)	3.76	0.82	0.76
<b>Metacognitive awareness inventory</b>			
Declarative knowledge	16.99	0.73	1.95
Procedural knowledge	15.89	0.69	2.21
Conditional knowledge	16.49	0.67	1.89
Planning	15.61	0.81	2.40
Monitoring	15.72	0.75	2.19
Evaluate	15.18	0.79	2.55
<b>Worldview test</b>			
Traditional worldview	3.06	<b>0.73</b>	4.58
Modern worldview	-4.64	<b>0.70</b>	4.20
Postmodern worldview	-0.08	<b>0.51<sup>a</sup></b>	3.46
Integrative worldview	3.32	<b>0.51</b>	3.37

Source: Van der Westhuizen 2023, p. 79.

<sup>a</sup>A correlation value of -0.08, -0.099 and 0.512 was added by an item (see De Witt et al. (2016)’s anthropology 3) with the other worldviews. This item was taken from the scale since it showed a negative association.

Key: AM, assignment management; OLP, online learning proficiency; SM, stress management; TP, technical proficiency; PM, procrastination management; ODP, online discussion proficiency; SLP, seminar learning proficiency; CC, comprehension competence; EM, examination management; TM, time management.

SDL is an integrative worldview. The measurement model was represented as Figure 10.3 by transposing the standardised regression estimates into a Word document. The link between SDL and an integrated worldview is depicted in Figure 10.3. As was previously said, a worldview is an attitude or point of view about the world that helps one make sense of and make sense of their life experiences. A worldview may be defined as a collection of life realities that form the basis of certain beliefs, ways of thinking and ways of doing. The worldviews of educators also influence how they instruct and are instructed. The integrative worldview and the visible realm of SDL have the highest correlation because integrative teachers are typically more adaptable in their approach to teaching than, say, a traditionalist teacher, who may be less adaptable and more set in his or her ways, thus not wanting to explore or model SDL. With CMIN/DF (1.790), CFI (0.855) and RMSEA (0.059) with a 90% CI [0.041; 0.076], the model is considered



Source: Adapted from Van der Westhuizen 2023, p. 102.

**FIGURE 10.3:** The role of a worldview in self-directed learning.

to have an excellent match. The third model addressing the connection between SDL, metacognitive awareness and integrated worldview is covered in the next section.

### ■ **Model 3: The visual and affective dimensions of self-directed learning play a mediating role in the link between metacognitive awareness and worldview, and the suggested model shows a strong match in this regard**

Model 3 focuses on how SDL is impacted by every statistically relevant feature of worldview and metacognitive awareness merged into one model. The model's parameter summary consists of 105 free parameters, 21 variances, 41 regression weights, three covariances, 21 means and 19 intercepts. The standardised regression estimates and  $p$ -values for the structural model illustrating the connection between SDL, metacognitive awareness and integrated worldview are presented in Table 10.5. The visual and emotional domains significantly influence metacognitive knowledge at the  $p < 0.05$  levels, according to awareness on SDL. As the regulatory  $p$ -values are higher than 0.05, they are not statistically significant.

**TABLE 10.5:** Reliability and mean inter-item correlations of the two self-directed learning domains (visible and affective).

Construct	Variable	Domain with number of items	Mean inter-item correlations	Cronbach's alpha ( $\alpha$ )	
Self-directed learning	OLP, SM, TP, PM, ODP, CC	SDL 1 Visible domain	6 Items	0.371	0.77
	AM, SLP, EM, TM	SDL 2 Affective domain	4 Items	0.307	0.64

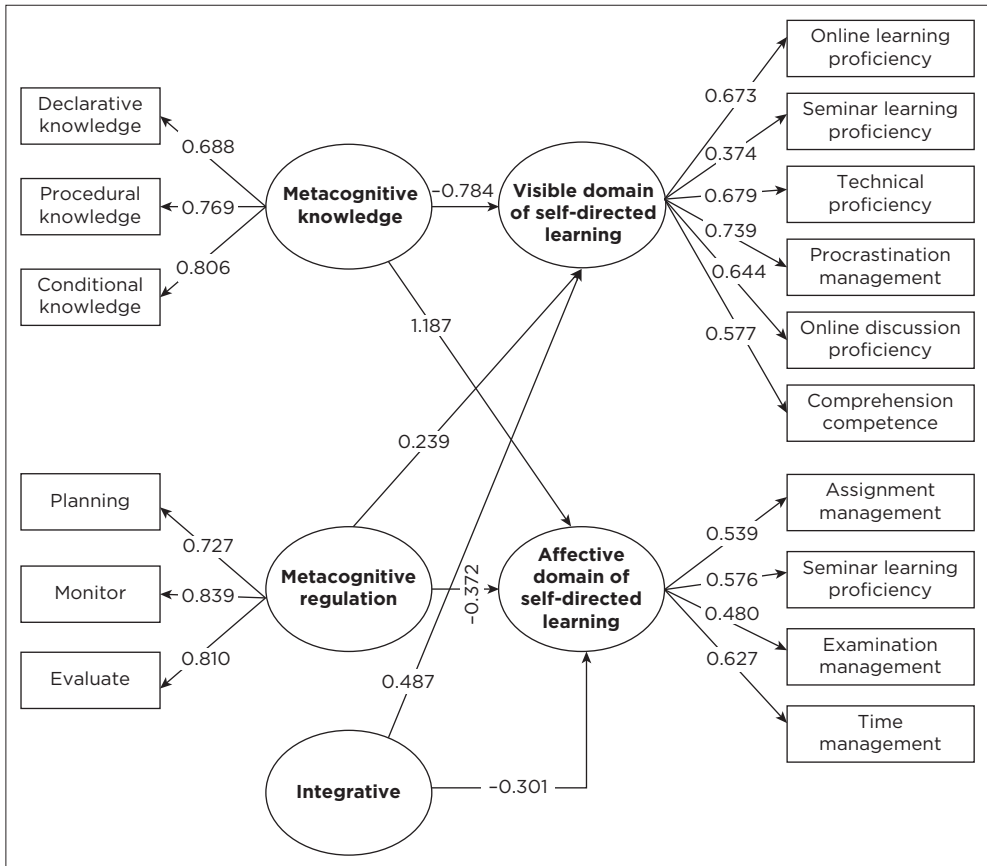
Source: Van der Westhuizen 2023, p. 98.

Key: OLP, online learning proficiency; SM, stress management; TP, technical proficiency; PM, procrastination management; SDL, self-directed learning; ODP, online discussion proficiency; CC, comprehension competence; AM, assignment management; SLP, seminar learning proficiency; EM, examination management; TM, time management.

Furthermore, at the  $p < 0.05$  levels, there is a substantial association between an integrated worldview and the emotive and visual domains of SDL. The measurement model was represented as Figure 10.4 by transposing the standardised regression estimates into a Word document. The association between metacognitive awareness and integrated worldview in both areas of SDL is depicted in Figure 10.4. This concept proposes that the growth of SDL is specifically aided by metacognitive knowledge. With CMIN/DF (1.583), CFI (0.918) and RMSEA (0.051) with a 90% CI [0.036; 0.064], the model is considered to have an excellent match.

## ■ Model 4: Teachers’ worldview has a direct effect on their self-directed learning

The statistically significant associations from Model 3 are the main focus of Model 4. The standardised regression estimates and  $p$ -values for the structural model pertaining to the correlation between SDL, metacognitive knowledge and an integrated worldview are presented in Figure 10.5. The correlation between metacognitive knowledge and SDL suggests that, at the  $p < 0.05$  levels, it enhances the visual and emotional dimensions of SDL. Model 4 suggests that the development of SDL is supported by metacognitive knowledge and an integrated worldview. Teachers may use the knowledge they acquire about their own ideas and beliefs to become more self-directed as they become more conscious of them. Self-directed learning is also supported by an integrative worldview because integrative educators are more open to adjusting to new methods of instruction and learning, which may involve changing their own ideas and opinions as well as their teaching methods in order to support their own SDL. With CMIN/DF (1.362), CFI (0.948) and RMSEA (0.040) with a 90% CI [0.016; 0.058], Model 4 is considered a fit.

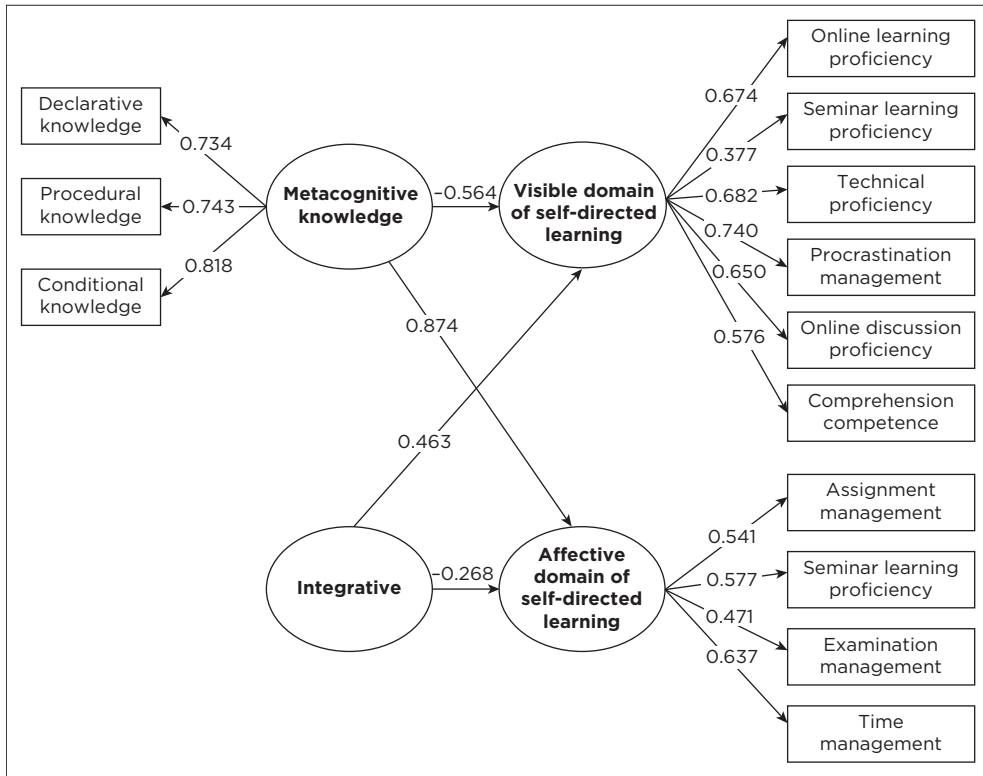


Source: Adapted from Van der Westhuizen 2023, p. 104.

**FIGURE 10.4:** Metacognitive awareness and worldview with the mediating role of visible and affective domains of self-directed learning.

## Discussion

The goal of the study was to ascertain how worldview and metacognitive awareness relate to one another as mediating factors that support SDL. The authors aimed to determine whether the proposed model could effectively determine the relationship between metacognitive awareness and worldview, taking into account the mediating role of the visible and affective domains of SDL. Additionally, they sought to ascertain whether teachers' metacognitive awareness directly impacted their worldview, whether teachers' worldview directly impacted their SDL and whether teachers' metacognitive awareness directly affected their SDL. Four models were created via structural equation modelling to bolster these theories.



Source: Adapted from Van der Westhuizen 2023, p. 105.

**FIGURE 10.5:** Integrative worldview, metacognitive knowledge and self-directed learning.

The results of the present study showed that there is a relationship between metacognitive awareness and the worldview of teachers. The directed effect of metacognitive awareness on SDL was affirmed on the metacognitive knowledge types (declarative, procedural and conditional). In other words, metacognitive awareness predicts SDL, mediated by metacognitive knowledge. One of the key contributions of this study is its focus on metacognition, or the ability to reflect on one’s own thoughts and actions. The authors suggest that individuals with a more developed sense of metacognition are better able to engage in effective SDL, as they can monitor their own progress and adjust their strategies as needed. This is an important finding, as it suggests that metacognition may be a key factor in promoting lifelong learning and personal growth.

Another important contribution of this study is its emphasis on the role of worldviews in shaping our approach to learning. The authors argue that our worldview, or our underlying assumptions about reality, influences how we approach new information and experiences. For example, individuals

with a more holistic worldview may be more open to new ideas and more willing to engage in SDL than those with a more rigid worldview. In summary, the models can be organised as follows:

- Model 1 suggests a continuous interaction between metacognitive regulation and metacognitive knowledge towards motivating an individual to take action and become more self-directed.
- Model 2 suggests a relationship between the integrated worldview and the visible domain of SDL.
- Model 3 suggests that metacognitive knowledge plays an essential role in the development of SDL.
- Model 4 shows metacognitive knowledge and an integrative worldview are conducive to the promotion of SDL.

In the proposed model, the metacognitive knowledge together with declarative, conditional and procedural knowledge as well as an integrative worldview can predict SDL. As the model indicates, two dimensions of SDL were confirmed in relating to metacognitive awareness and worldview.

The authors argue that worldviews play a crucial role in shaping how individuals approach the process of SDL, and they propose a model for understanding this relationship in more detail.

## ■ Understanding worldviews, metacognition and self-directed learning can significantly benefit teachers in several ways

**Customised Teaching Approaches:** Worldviews shape how students perceive and engage with learning. Teachers aware of diverse worldviews can adapt their teaching strategies to accommodate different perspectives, creating inclusive and engaging learning environments.

**Enhanced Learning Strategies:** Awareness of metacognition helps teachers guide students in understanding their own learning processes. Teaching metacognitive strategies empowers students to plan, monitor and evaluate their learning effectively, fostering autonomy and self-regulation.

**Promotion of SDL:** Knowledge of SDL allows teachers to design learning experiences that encourage students to take ownership of their learning journeys. They can provide resources, guidance and opportunities for students to set goals, manage their time and evaluate their progress.

**Cultivation of Critical Thinking:** Understanding different worldviews and promoting metacognition can encourage critical thinking. Teachers can facilitate discussions that challenge assumptions, encourage diverse perspectives and promote reflective thinking among students.

**Individualised Learning Support:** Recognising various worldviews helps teachers understand individual student needs and preferences. Teachers can offer personalised support by acknowledging diverse learning styles, preferences and cultural backgrounds.

**Adaptation of Teaching Methods:** Knowledge of different worldviews allows teachers to adapt instructional methods that resonate with students' values and beliefs, making learning more meaningful and relevant.

**Assessment and Feedback:** Incorporating metacognitive strategies in assessment and feedback processes enables students to reflect on their learning progress and set goals for improvement. Teachers can encourage self-assessment and reflection to enhance learning outcomes.

**Encouragement of Lifelong Learning:** By promoting SDL skills and embracing diverse worldviews, teachers foster a passion for learning in their pupils and provide them with the resources they need to continue their education outside class.

These concepts provide valuable insights and tools for teachers to create inclusive, supportive and effective learning environments. By leveraging these principles, educators can empower students to become self-directed, critical thinkers capable of navigating a diverse and evolving world.

## ■ Conclusion

Teachers who understand diverse worldviews can tailor their teaching methods, creating inclusive environments. Awareness of metacognition empowers teachers to guide students in understanding their learning processes and promotes autonomy. Self-directed learning knowledge enables teachers to design experiences that foster student ownership and growth. Encouraging critical thinking through diverse perspectives and metacognition enhances learning. Recognising varied worldviews helps teachers provide personalised support, adapting methods to resonate with student values. Incorporating metacognitive strategies in assessment cultivates reflection and goal-setting. Overall, these approaches promote lifelong learning skills and a passion for continual growth beyond the classroom.

The world of education is one of the many dimensions that make up our universe. This implies that a person's perspective regarding education is directly influenced by how they see and are aware of the reality of teaching and learning (Jagals 2015). This implies that the coexistence and co-construction of the worldview of persons inside this environment are

what creates a world of teaching and learning, not the other way around (Jagals 2015; Töman 2017, p. 233). Teachers and students hold their own epistemological and pedagogical beliefs inside the frameworks known as worldviews, which are cognitive, intangible and influential (Dimov et al. 2015, p. 1301). These can include attitudes about classroom instruction, beliefs about the origins of information, ideas about how learners acquire knowledge and beliefs about the role of a teacher, among other beliefs that educators may struggle with (Dimov et al. 2015, p. 1302). What is still needed is a conceptual bridge, one that marks the transition from a traditional to a more integrative worldview. Other data collection instruments such as interviews can promise more insight or an in-depth understanding of teachers' worldviews. Metacognitive awareness acts as a key regulator in this process and when metacognitive awareness is facilitated, the liminal portal through which we might view the world of education and a transcendent source of SDL.



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## Preface

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### Chapter 3

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## Chapter 4

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## Chapter 7

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## Chapter 8

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This book presents cutting-edge academic research in education, focusing on utilising metacognition to enhance self-directed learning. As the thirteenth volume in North-West University's Self-Directed Learning Series, it aims to develop students' metacognitive and self-directed learning skills, which are essential for thriving in the 21st century. Metacognition plays a pivotal role in planning, evaluating, and self-assessing the learning process, fostering reflective and independent thinking that allows students to apply their knowledge to new contexts. Research indicates that students with strong metacognitive abilities achieve better learning outcomes and exhibit superior self-directed learning skills. Metacognitive strategies boost students' awareness and control over their learning, enhancing their self-regulation, motivation management and persistence.

This book contributes new insights into how educators can support the development of metacognition and motivation to enhance self-directed learning in diverse educational settings. It investigates teaching behaviour and teaching strategies that promote metacognitive skills, self-regulated learning and motivation for self-directed learning. By examining these aspects within the South African education landscape, the book extends research in educational, developmental, cognitive and applied psychology. It addresses key research questions in both basic and higher education by assessing major theoretical themes and applying them in real-world contexts. Additionally, the book explores the use and understanding of metacognition across various disciplines, offering practical teaching strategies for both graduates and undergraduates in education.

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This compendium of chapters will certainly enhance the reader with an arsenal of perspectives related to self-directed learning and contextual underpinnings for enhancing the experiences of learners. Creating environments where learning and thinking are paramount considerations, this collection of chapters may act as a catalyst for facilitating the learner's self-directedness that many educational endeavours systematically and deliberately removed from programmes of study due to difficulties associated with quantifying learning. If one is interested in lecturing and testing for the right answers, hopefully this compendium of chapters will act as a catalyst for learning in your specific context as well. Please make the time to think about the constructs presented within this text and have the audacity to facilitate learning.

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