Routledge Research in Educational Psychology

EMBODIED LEARNING AND TEACHING USING THE 4E COGNITION APPROACH

EXPLORING PERSPECTIVES IN TEACHING PRACTICES

Edited by
Theresa Schilhab and Camilla Groth

"Overall, I consider the book to make an excellent contribution to 4E cognition-inspired research on learning and teaching at various levels and areas of education. The chapters apply the 4E cognition framework insightfully in their respective contexts. I enjoyed reading the chapters very much and felt that many of them make an outstanding contribution to the field."

— **Professor Kai Hakkarainen,** *Department of Education, University of Helsinki, Finland*

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Embodied Learning and Teaching Using the 4E Cognition Approach

This book operationalises the new field—EmLearning—that integrates embodiment and grounded cognition perspectives with education using the 4E approach as a guiding principle, which suggests that cognition is embodied, embedded, enacted, or extended.

Chapters highlight empirical data, providing readers with research-based insight into the theoretical foundations of embodied cognition in learning, illustrated by practical examples. Ultimately, the volume contributes a radical understanding of embodied cognition, demonstrating the importance of the field to the educational system more broadly and suggesting a fundamental change to the way learning, education, and curriculum design are viewed and considered. Based on contemporary scientific findings, the book addresses the educational area with a focus on opening the embodied approach to a wider audience that will circulate the new knowledge and support their educational practices.

Written with the purpose of contributing to a broad spectrum of academic educational fields, this book will be of use to postgraduates, researchers, and academics in the fields of higher education, educational psychology, teacher education, and teaching methodology and practice. Teachers and school politicians should also benefit from this volume more broadly.

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Exploring Perspectives in Teaching Practices

Edited by Theresa Schilhab and Camilla Groth

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Figure 0.1 Embodied social and environmental interaction through tree-climbing. Photograph by Anastasia Shuraeva.

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Preface

This anthology has grown from a collective effort of networking activities named EmLearning—the Nordic network of embodied learning (2020–2022), funded by the Joint Committee for Nordic research councils in the Humanities and Social Sciences (NOS-HS), which promotes Nordic research within the humanities and social sciences. The network consists of European researchers representing a broad array of disciplines with research interests and experiences of how to apply embodied cognition perspectives to educational practice.

Based on research within this novel approach, the network aspires to establish EmLearning as a field and to stimulate and inspire a playful and accommodating way of teaching to create better and more holistic learning opportunities for pupils. We also strive to nurture the teaching profession with a more humane and adaptive mindset that enriches professional life.

We are deeply grateful for the generous, thoughtful, and highly productive contribution of Professor Kai Hakkarainen, Department of Education, University of Helsinki, Finland. His significant insight and suggestions as an anonymous peer reviewer significantly influenced the anthology.

We are also grateful for all the help and support by our superb English language reviewer Jess Kelley, who meticulously and gracefully aligned and shaped the contributions into their present form.

Theresa Schilhab and Camilla Groth

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Part I

Introduction

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1 Introduction to the anthology

Theresa Schilhab and Camilla Groth

Learning is embodied

Imagine some of the learning stages you have passed to reach the developmental level where you are today. From your time as an infant in the cradle, reaching for the moving colours hanging from the mobile above your head, to the dinner situation where your hands struggled with finding the right mix of relaxation and tension handling cutlery while your family offered guidance and support, to the endless hours in the classroom, struggling with reading and writing among classmates to cope with the sound and vision of the alphabet.

However diverse, these learning activities entailed that you were in a particular location framed by a specific cultural and social intent, affording and allowing certain behaviours and specific physical actions involving concrete materials in the form of items and artefacts. In all stages, the common denominator was that learning occurred with and because of you inhabiting your body—and that this body was interacting and exchanging with concrete environments and objects which co-constituted the learning. The reaching for distant colours, the challenge of the knife and fork, and the mastering of forming meaningful words from sentences in a book occurred because you were there, situated, interacting with mobiles, cutlery, and sentences in books, investing your mind and body in both informal and formal tasks making sense socially. Even "seeing" is something you have learned since even if you had visual experiences as a baby, you did not know the meaning of what you saw until you experienced approaching objects or understood how perspectives change as you move through a room (Noë, 2006). Only through repeated interactions with, and embeddedness in particular environments, did you become familiar with, the world as you know it today (Bahrick & Lickliter, 2002). This characterisation of learning and knowledge as experiential elements of lived life not only pertains to the early phases of an individual's life but remains constitutive of learning and knowledge acquisition throughout life. Consequently, embodied aspects of learning are also pivotal to learning and teaching in school—the central topic of this anthology.

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The science of embodied cognition

In contemporary cognitive science, the emphasis on embodied aspects of learning is on the increase. Within the last three decades, a new scientific field has emerged, termed "embodied cognition" (Varela et al., 1991). The name serves as an umbrella term for research revolving around cognitive topics like learning, thinking, understanding, knowledge, experience, and cognition from the perspective of the body. Consequently, the concept of "cognition" reaches far beyond what goes on in the head and applies to the much wider conception of what could be referred to as meaning-making. The field is highly multidisciplinary and builds on, for example, anthropology, psychology, AI research, neuroscience, the brain sciences, linguistics, philosophy, and sociology (Barsalou, 2010). This "new" perspective is not just another perspective in cognitive science but a new understanding of how the human being is learning—this paradigm shift in cognitive sciences fundamentally changes the understanding of how learning happens. But what are the 4Es, and how does this perspective differ from other ways of thinking about learning, such as the cognitivist perspective that has formed the educational theory up until very recently? Embodied cognition views learning and knowledge as relational phenomena in a living body resonating with its social and physical environment, illustrated by the diverse, imagined learning situations in the opening paragraph of this chapter. Consequently, the essence of embodied cognition has been popularised under the name "the 4Es": the mind is embodied, enacted, embedded, and extended (Menary, 2010; Newen et al., 2018; Wilson, 2002).

Embodied: Cognition is embodied in that it happens in the service of the body (Maturana & Varela, 1987). From an evolutionary perspective, cognition arose to preserve the body through and through. Thus, cognition is not to be viewed as the mental outcome of neural processing and cannot be isolated from the body, which plays a constitutive role in learning (Deacon, 2011). Consequently, educational practices need to be grounded in a thorough understanding of the bodily nature of cognition (Kiefer & Trumpp, 2012). Through social and material engagement, learners gain experiential knowledge and skills that are internalised and later automised and become second nature, such as walking or seeing.

Embedded: Cognition is always embedded and situated in a context that is consequently also affecting how something is learned. This may be a specific physical environment and/or a social context—for example, learning in nature will be different from learning inside a classroom. The community of other learners, teachers, and the general setting and traditions for learning also affect the situation of learning (Brown et al., 1989).

Enactive: Cognition emerges from or is constituted by sensorimotor activity (Noë, 2006).

Engagement with materials and technologies affects the nature of what is perceived, learned, and understood (Malafouris, 2013). This view is also closely related to a concept called the action-perception loop, which explains

the process of learning from previous experiences in an ecological sense. Through repetitive interactions with our social and material world, we learn to make more realistic expectations and better align our own behaviour and actions in future encounters with similar situations (Clark, 2013). Another strand of embodied cognition theories explains this through the concept of "affordances". These are opportunities for actions that a person might utilise in their environment and that are usually—but not exclusively—presented as visual cues. Gibson's (1979) ecological psychology, which lies behind the theory of affordances, has been important for the development of embodied perspectives on cognition, as it is based on the organism's active engagement with its environment. Thus, perception is not reduced to mere processing of incoming information but is always already anticipating the information and what happens next at the level of the body (Barsalou, 2015; Rowlands, 2010).

Extended: Sometimes thinking about something in one's head is not enough, and to help ourselves in a task, we may "off-load" cognitive load by using external aids. Cognition may be extended through technologies and tools such as writing or note-taking to remember something or the use of fingers when counting a complicated mathematical problem (Abrahamson & Lindgren, 2014). Digital technologies afford considerable opportunities for extending cognition beyond the body (Chemero, 2013; Clark & Chalmers, 1998) but also fundamentally affect the quality and form of learning—for example, reading from a book may be quite different from reading on a screen.

The numerical claim lingering to the term "4E" is not to be taken literally, though. The paradigm is currently only at the brink of an established line of thought—a stage which the philosophers of science would label as pre-paradigmatic and thus characterised by many conflicting views (Kuhn, 1962). Hence, embodied cognition proponents openly discuss to what extent the 4E-label fits with and encompasses the entire field or whether more aspects should equally become enumerated. Some researchers argue for replacing extended with ecological, whereas others propose to add Es like emotion (affection) to the bunch.

However, inherent to the conjecture is that the 4Es are preconditioning all learning with no exceptions. Irrespective of whether the learning in question is basic (such as how to balance a cup, reach for mobiles, or learn to walk) or sophisticated (such as how to read or construct a persuasive argument), the 4Es form the backdrop of the learning in question.

It is worth noting, however, that the 4Es—including putative future Es like ecology, emotion, and probably more—are co-involved and contribute to any learning activity, and cannot be viewed as occurrences in isolation. Also, extended mind learning does not exclusively pertain to mere interaction with external objects. Quite the opposite: extended learning, like using fingers when learning to count, becomes internalised mental processes that reduce introductory overt interactions to distant reminders of the material engagement of the learning.

The consequence is that even operations that would be thought of as "mental" are embodied through and through. Not merely as a result of taking place in a mind in a body which is embedded and responding to both physical and social affordances but as a result of the content of the mental operation bearing the mark of embodiment. For instance, when we think about a future birthday, our thoughts take their form from already experienced birthdays (Schacter et al., 2017). Abstract and rational thoughts, planning and hypothesis creation, and fantasies and imagined futures all rest on embodied, directly experienced encounters with a highly material and sensory world.

This suggestion is quite radical when considering it to its full potential. Fundamentally, the body and its involvement with the world determines learning—also in those instances where apparent connections with the body seem absent, such as learning in virtual games or when controlling thoughts apparently purely linguistically, as exemplified by reading.

Hence, when pupils read about universes, they have never experienced first-hand—say, distant destinations or even places out of space—they must rely on their knowledge of the worlds they have already received (Klomberg et al., 2022).

Embodied cognition means, in short, that the body gains a fundamental role in both cognising and learning, something that mainstream learning theories have neglected to a large degree (Kiefer & Trumpp, 2012; Wilson, 2002). However, even before the 4Es were developed, a few learning theorists have intuitively acknowledged the situated nature of learning (Brown et al., 1989), and the experiential aspects and learning through doing (Dewey, 1938). Socio-material learning theories have also, since Vygotsky (1978), acknowledged that learning is distributed into the social environment of the learner (see also Hutchins, 1995); the 4Es confirm much of these early learning theories.

Embodied cognition as a learning theory

As a learning theory, embodied cognition emphasises the impact of the present and the perspective of the body. There cannot exist a view from nowhere. All learning is through and through embodied, perceptual, biased, and sensorially rich, involving and evolving the learner and the world to an extent that transgresses traditionally conjectured boundaries. When we learn in the now—be it how to cook a bowl of rice, how to sew a pair of trousers, how to compute the division of numbers, or how to interpret the Shakespeare drama of King Lear—we are situated bodies using present and previous experiences to cope with the next steps.

However, emphasis on the embodiment perspective does not accentuate the now in the sense one might suspect: that the historical and the cultural aspects of human life are downplayed. According to an article by the emotional psychologist Louise F. Barrett (2009), each moment of our "mental now" draws on three different sources—namely, sensations of our

surroundings, sensations of our interior, and our memory. Consequently, in the embodied cognition perspective, the extended and embedded mind is also about how the sociocultural works by allowing, affording, and subsequently cultivating particular behaviours and endeavours, thus creating and conditioning the paths we have trod and will tread in future.

However, the educational system—e.g., teachers, schoolmasters, and school politicians—is not sufficiently informed about the potentialities and implications of this insight at the curricular level. This book seeks to amend this.

Rationale for the anthology

When addressing the operationalisation of 4E into educational contexts, one way to begin is to explore the implications of the 4E approach for learning in school. Which consequences for teaching should we derive from reconsidering the role of the enactive body embedded in the social and physical environment interacting with tools and artefacts? Acknowledging that the embodied cognition approach is still an emerging framework typically motivated by proof of concept, few scholars have crossed the bridge between embodied cognition and teaching to search for take-home messages relevant to teachers and educational practitioners (Macrine & Fugate, 2022).

Therefore, this anthology aims to establish this new field in the wake of 4E cognition—EmLearning—that integrates embodied cognition perspectives with education using the 4E approach as a guiding principle. The objective is to explore the implications of the approach—i.e., that learning is based on experiences, is highly perceptual, embodied, situated, and interactional in the sense of involving interactions with materials and the physical and social surroundings.

The current compilation takes this challenge seriously. From the perspective of traditional school disciplines—reading, second language learning, technological literacy, science learning, and learning through making—the reader learns about the potentialities and challenges of pursuing teaching and learning in school from the embodied cognition stance.

A few notes relating to the content of the anthology are worth considering. First, teaching how to read and write receives relatively more attention, as these skills precondition most other school subjects. Hence, the first section of chapters provides a general approach to embodied cognition in language acquisition, whereas the following sections contain chapters directed at reading and writing, nature, science and technology, and the aesthetic and practical disciplines.

Second, due to the broad range of disciplines among contributing authors, different interpretations of the central terms exist. While some authors build on a phenomenological heritage when discussing embodiment perspectives, others refer to anthropological associations or are neurobiologically inspired. These are separate philosophical and scientific positions with quite distinct implications. Therefore, most authors explicitly address which kind of

embodied cognition position their chapter endorses and most of them also write explicitly how their theme connects to the 4Es.

Given the uncertainty within embodied cognition about a finite set of Es, in this anthology, we acknowledge that more embodied aspects are likely to be specified in the near future by introducing the notion 4E(+). With this move, we allow for additional Es to contribute to charting the landscape and acknowledge that reality never conforms to artificial categories. It always bulges out of the form so insistingly cast upon it by the analytic propensities of the human mind to simplify and control. This more inclusive approach seems feasible to adopt when establishing EmLearning as a field in its own right, focusing on challenges and prospects from the educational and teacher points of view.

It is our ambition to inspire you, as a teacher, to adopt an embodied perspective in your teaching practices. With this compilation of chapters, we invite you to explore where and how to find embodied aspects of teaching. We also hope to support you in finding new trajectories that accommodate embodied cognition learning in your pupils by providing case examples and reframing the learning in terms of 4E. Our objectives are to stimulate and inspire a playful and accommodating way of teaching that improves learning opportunities for learners—especially those who have been challenged by traditional teaching strategies—and to enrich the teaching profession with a more humane and adaptive mindset that delivers more rewarding solutions to tasks.

Anthology structure

We set the scene of the anthology with Lydia Kokkola's chapter 2 "Languages are grounded in the body", a comprehensive introduction to a range of fundamental associations of language with the body. Kokkola presents updated knowledge on the phylogenetic evidence of the development of language capacities and touches upon studies addressing conceptual metaphors. Kokkola also explains how bodily interactions in a social and cultural environment underlie meaning-making in language activities and unfold how, for example, second language teachers can benefit.

The chapter 3 "Exploring reading aloud events through embodied learning: impacts on early literacy" by Theresa Schilhab, Gitte Balling, and Gertrud Lynge Esbensen, operationalises several of the associations between language and embodiment discussed in the opening chapter. The authors conjecture that the benefits of reading aloud for early literacy in preschoolers can be explained using the 4E(+)s as backbone structure. The unfolding also leads to a model charting reading aloud processes to be adopted by practitioners.

Pauline von Bonsdorff and Aila Marjomäki present a comparable use of 4E principles in primary school in their chapter 4 "Inclusive language teaching". Through examples from Finnish primary schools, this chapter discusses how the 4E principles can be implemented in inclusive language teaching. Bonsdorff and Marjomäki report from two reading courses that show structure with plenty of room for children's individual and self-organised group work while the

teachers' enable the learners' literary analyses and storytelling. The authors unfold how the courses, among other things, also supported positive cascades of learning and personal growth in the pupils.

The chapter 5 by Sarah Bro Trasmundi and Anne Mangen, "Substrates, displays, technologies, and texts: embodied, experiential reading", continues the unfolding of relations between language and embodied cognition perspectives, now zooming in on reading activities in particular. Contemporary research of new digital reading platforms has led to reconceptualisations of reading using embodied cognition perspectives. This seems particularly promising as it renews the status of material affordances of the media or artefacts in reading. It also redefines reading as an embodied, multisensory engagement with a text.

In the chapter 6 "Embodied learning with and through different writing methods" by Satu-Maarit Korte and Minna Körkkö, the impact of changed writing affordances is empirically explored. The chapter refers to studies that examine differences in memorising written texts amongst children, adolescents, and adults when handwriting or typing on a laptop, tablet computer, or smartphone. The chapter reflects on the results to formulate practical instructional recommendations for teachers.

Kristiane Hauer takes up the thread of embodied reading to discuss how to best accommodate long-form silent reading in the chapter 7 "Long-form silent reading in the contemporary classroom". The chapter presents empirical cases from primary and secondary schools in Denmark to address the challenges pupils face when engaging in long-form silent reading. The chapter summarises the findings by formulating practices that promote pupils' experiences of success.

Juan Toro and Sarah Bro Trasmundi's chapter 8 "Education in the cognitivist and embodied paradigms. Why won't my students read?" is similarly directed at the challenges confronting reading pupils. In this chapter, the teacher's furnishing of the reading situation is analysed. Toro and Trasmundi conjecture that inaccurate ideas pertaining to the reading process, inspired by cognitivist conceptions, have led to counter-productive reading didactics, leaving demotivated pupils in their wake. They turn to the embodied cognition perspective to build more ecologically valid and sustainable reading didactics.

In the chapter 9 "Thinking through hands in education", Camilla Groth and Marte S. Gulliksen offer a coherent theorisation about how thinking is a process that rests on a sensory connection with the world. Special attention is paid to hands and learning through making and the "sense-making" that takes place in material engagement. The chapter presents examples from the craft practices and expands on how the processes offered by material engagement help students gain resilience, patience, and problem-solving skills that are also relevant to other school disciplines.

Lovise Søyland picks up on a number of theoretical points made by Groth and Gulliksen in her chapter 10 "why whole-body drawing still matters in our digital age". Through autobiographical explorations, Søyland reflects on how a person's thinking is mediated through material interaction and specifically explores how drawing may be seen as a way of thinking. In her whole-body drawing experiences over a few days in the freezing temperatures of Norway, we become first-row spectators to the merging of the body with charcoal, paper, and thought. Søyland concludes by offering implications for education.

In the chapter 11 "Apprenticeship as a model for teaching and learning in formal education," Camilla Groth argues for the benefits of contextualisation of the practices learned in the formal classroom setting. Groth highlights the situated qualities of apprenticeship and discusses these in light of embodied cognition theory. To unfold their implications for teaching, Groth uses a case in clay throwing based on her expertise and her online teaching of students during the COVID-19 pandemic. The chapter embraces both the embodiment inherent to apprenticeship and the potential of new technologies to import some of the situatedness to the classroom through live video connections.

The chapter 12 "Conceptualising technology-enhanced embodied pedagogy" by Satu-Maarit Korte and Minna Körkkö reflects on the potential of technological solutions in primary school in light of embodied cognition aspects. Based on two significant cases, the chapter unfolds and explains how technological solutions can motivate and inspire by, for instance, stimulating agency and pupils' ownership of their learning. The authors summarise their reflections in a model which operationalises the potency of technology when used ingeniously.

Gertrud Lynge Esbensen, Theresa Schilhab, and Gitte Balling follow up on the previous chapter to take the association between embodied cognition and smart technology use to the outdoors in "smart technology in nature-based learning—embodied and situated processes". The chapter 13 explores nature-based teaching through smart technology use, from the perspective of embodied and situated cognition as a means to simultaneously stimulate nature-connectedness and technological literacy. The authors also discuss which challenges to consider when using smart technology to promote experiences of nature

In the chapter "How nature-like artworks induce perceptual processes benefitting education in general and science education in particular" by Theresa Schilhab, the focus is on perceptual processes as important precursors for learning in general and for science learning in particular. Based on the author's reflections on an exhibition and art teaching practices at an arts centre, the chapter discusses to what extent experiencing nature-based artworks stimulates and cultivates perceptual processes and how these may depart from perceptual processes that occur in nature

Alexander Refsum Jensenius' chapter 15 "Embodied music learning" presents the term "musicking" using the embodied cognition framework. The chapter outlines different ways we may relate to musical activities, from a theoretical understanding of music, to actively listening, through to actual music-making. Further, Jensenius addresses how music education in school may become more embodied when adopting more interactive and flexible attitudes to musicking, and perhaps also using contemporary music technologies. He corroborates his assertions by sharing how he developed his own embodied didactics with his students.

Gunn Helene Engelsrud focuses on the integrity of the individual in her chapter 16 "Teaching and learning in physical education teacher education" from the perspective of "bodily resonances" and "letting be". Engelsrud addresses the subjective space between the teacher and the pupil as something the teacher can inhabit when opening themselves to the first-person experience of the pupil. The chapter presents the idea that education and the learner's personal development and formation can benefit from working with emotional and embodied tacit processes at the level of the individual pupil and thus challenges the "one-size-fits-all" kind of classroom teaching.

The chapter 17 "Embodied learning in interaction: the case of aikido" by Susanne Ravn discusses specific instances of resonating with the other using the case of practising the martial arts form aikido. Ravn explores several of the processes presented in the former chapter in an actual intersubjective encounter between actors. Through her own experiences of aikido, Ravn's case unfolds how practitioners develop their skills and abilities to participate not only in relation to, but through, the movement of the other.

In chapter 18, Camilla Groth and Theresa Schilhab sum up the take home messages of the preceeding chapters to frame the contours of the emerging field of EmLearning. The chapter concludes with a check list with the dual aim of creating an overview of the topic and nudging the readers to embody Emlearning in their own practices.

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Part II

Language as lived experience

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2 Languages are grounded in the body

Lydia Kokkola

The existence of many different languages has led to the suggestion that word-meaning connections are arbitrary. This is partly true, but from the perspective of language learning, the embedding of languages in a particular context and its enactment by the community are more important. Analyses of language in use reveal that seemingly "arbitrary" expressions are less random than they might appear. The phenomena known as "conceptual metaphors" reveal how language is used to extend thinking. Many conceptual metaphors are connected to how the human mind-body functions. The chapter concludes with a few comments on the implications of the aforementioned for education.

The evolution of the first language

The human body has evolved to learn the languages heard in the infant's environment. Unlike for reading, history, geography, or many other school subjects that require extensive experience to achieve mastery, our bodies evolved to learn languages. This learning begins prior to birth. Newborns are able to distinguish the cadences of their mothers' voices (Bader-Rusch, 2003; Moon et al., 2013). Infants' hearing systems quickly learn to recognise, discriminate, and categorise sounds that are present in their environment, which results in less attention being paid to sounds that are not meaningful (e.g., Imada et al., 2006). At 2 years, they can produce novel utterances, and by 5, they can communicate information about the here and now, recall the past, and hypothesise about the future. Only extreme disability and/or abuse can prevent a child from learning their first language. The same cannot be said of second language acquisition, which is characterised by significant individual variation (e.g., Cook, 2016, pp. 135–54; Ellis, 2004). Adult immigrants who learn a language after puberty frequently "sound foreign" in terms of both pronunciation and grammar, whereas their young children do not. Such differences indicate that young children have richer perceptual detectors than adults but also that such openness is not efficient in the long term. Honing the perceptual field down to the language(s) encountered in early childhood can be assumed to have an evolutionary advantage, not least because of the strong social bonds that are formed and maintained through language.

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Noam Chomsky's attempts to explain this phenomenon in the 1960s had a significant impact on the field of linguistics (for a summary, see Chomsky, 2002). Chomsky was fascinated by children's production of grammatical forms they had never heard, as this indicates that language is not learned solely through imitation. He proposed that humans are born with a "Language Acquisition Device" (LAD) which enables infants to latch onto specific features of the languages in their surroundings. He further proposed that there must be a Universal Grammar (UG) underlying all languages, which the LAD is designed to detect. The concept of the LAD was inspired by the appearance of computers. Chomsky's idea was that the infant brain has a sensitivity to certain phonetic, grammatical, syntactical, and semantic features. A limited number of examples suffice to "throw a switch" in the LAD that would enable them to learn rapidly. His studies of children's grammatical development, known as "generative grammar", were partially aimed at uncovering UG. We now know that there is no neurological evidence to support the existence of the LAD (Kauppinen, 2020, pp. 193–7). As Michael Arbib (2012, pp. 285–6) explains,

> [T]he very diversity of human language makes it clear that, whatever the extent of biologically based universals that may unite human languages, most of what defines any specific language is rooted in a cultural, rather than biological, process of historical evolution.

However, he claims that the human brain evolved to be "language ready" (Arbib, 2002, p. 24). Studies of children's grammar have proven useful for both educators and phonologists, but innatist claims following Chomsky are unsupported by evidence.

More productive evolutionary accounts of language acquisition draw on two different kinds of data. One is to investigate archaeological (i.e., skeletal and fossilised) remains to investigate the impact of language on the body. Given the vital role of the throat for breathing and eating, using it for language can be considered a high-risk activity. Archaeological remains indicate that language emerged around 100,000 years ago and can be seen in changes in the throat mechanisms (Donald, 1999; Kauppinen, 2020, pp. 193–7). Interestingly, this bodily change is still visible today in the second type of evidence used to support evolutionary theories: comparisons between primate bodies. Newborn humans, like monkeys, have a larynx that is lower than the larynxes of people who can speak. They need to learn to swallow without choking (hence the need to pat babies' backs after feeding). Fairly rapidly, babies learn to separate the different functions of the throat, thereby allowing language to emerge.

A number of evolutionary theorists have compared the development of babies with other primates. Giacamo Rizzolatti and Corrado Sinigaglia (2008), as well as Arbib (2012), have focused on the mutuality of gestures, actions, and emotions, as well as neurological evidence to propose *the mirror system hypothesis*. This hypothesis proposes that mirror neurons allow all primates to learn by imitating, but only humans are capable of the level of imitation needed

to support the breakthrough into language. Michael Tomasello (2019) noted that children are better at copying than chimpanzees. He describes his theory as "new Vygotskian" as he highlights the role of interaction in learning, identifying what he terms the "9-month revolution" when infants start to use their hands to point out things they want information about—e.g., noticing a toy (Tomasello, 2019). From an embodied perspective, the key point about the studies comparing primates is that human language emerges in the context of a broad range of gestures, non-words (e.g., "uh oh"), exaggerated facial expressions, and joint attention. Language emerges *after* initial communication has been established through a sequence starting with turn-taking (e.g., mutual gaze, smiling, laughing), gesture (e.g., pointing to identify a shared point of attention), pantomime (e.g., acting out a routine associated with going to bed), and protosign (conventionalised gestures, such as blowing to indicate that the food is hot). In short, words (protospeech) emerge in a context where the whole body is being used to communicate. It is first shared and then gradually develops as a tool for thinking.

The evolutionary advantages of human language are obvious. While many animals and birds can communicate what is happening in the here and now (e.g., warnings that predators are coming), few animals seem able to communicate information about past events. (Many species mourn, which indicates the capacity to reflect on the past.) "Deferred imitation"—acting out an event that happened earlier—starts to appear in children's play from about their first birthday. Although infants may imitate behaviours (e.g., actions related to their sleeping routine) earlier, at the age of 1, children begin to playfully imitate behaviours which they know are "wrong", such as a change in the sleeping routine and then laugh to show that they know this is "wrong". This type of play appears to be a prerequisite for language development.

Language as embodied, embedded, enactive, and extended

In the previous section, I rejected what is known as the *code metaphor*. This term describes the belief that language is somehow "inside" us and/or that the brain produces linguistic forms. Adopting a 4E approach to language requires researchers to examine how the whole human body in its lived environment produces meaning through language, and also how language extends our possibilities for meaning-making beyond the here and now. Stephen Cowley (2014) summarises:

> [E]mbodiment links phenomenal experience to verbal patterns as, during ontogenesis, humans become actor-observers. In so doing, speaking and cooperating come under a degree of collective control. People gain skills in using a multi-scalar linguistic resource that allows embodiment to evoke impersonal products as people manage later events.
>
> (p. 2)

Cowley highlights the human body acting in the world, but as already noted, language also changes the body. Evolutionary archaeologists have discerned when pre-humans began to use language from its impact on bodily remains. The lowering and enlarging of the larynx are *embodied* features of language that can be detected from remains. Other changes in the body are also evident, for instance, the lengthening of the vocal cords during puberty, resulting in a slightly deeper voice that is easier to hear. These changes also limit the range of sounds a person can hear and produce, which is the key reason why it is so difficult to gain "native-like" pronunciation in a language learned post-puberty. There is a two-directional embodied process: the body produces language, and language production shapes the body.

Language is also *embedded* in a rich context of shared attention, gestures, and other bodily movements. In *Learning How to Mean*, Michael Halliday (1975) highlighted the child's active role in this process. His empirical evidence showed how early language is divided into functional units rather than grammatical units. These functional units are typically a combination of vocal utterances and gestures: the child might grab a hand to mean "come here" and use their own words to ask for drinks or a specific game. Conversation emerges as the child offers a sound in a gestural context, and the adult responds by extending the speech and providing the desired action.

Language is *enacted* as caretakers treat the infant as a conversational partner, combining voice, gesture, gaze, and contact with the surroundings. At around 12–14 months, infants develop the capacity to use language to move beyond the here and now, recalling events in the past, anticipating events in the future, and expressing humour through deliberate misalignment.

Once language has developed to the extent that it can refer beyond the setting, language can *extend* cognition, making it possible to think about abstract concepts. Literacy extends cognition even further, partly because it reduces pressure on the memory systems and partly because it is more precise. Becoming literate also changes our bodies: The pathways in the brain are affected by learning to read (Wolf, 2008). For instance, learning that the letters p, b, d, and q are discrete involves overcoming object permanence that allows us to recognise physical objects irrespective of the angle from which it is viewed. This capacity for extending cognition by producing permanent language (writing) is worth celebrating but has distracted attention from the fully embodied, embedded, and enactive aspects of language.

The 4E nature of language not only affects the way in which it is learned but is also evident in how it is used (e.g., Matheson & Barsalou, 2018). Languages are symbolic systems that enable humans to extend cognition through time and context. Early work by Ferdinand de Saussure (1916/2011) drew attention to the arbitrary nature of the connection between the form of a word, known as the "signifier" (e.g., "open"), and the concept it represents (e.g., the shop is open for business). The arbitrary nature of language is also evident in the existence of many languages. Instead of the word "open", the card on a shop door might read "auki", "öppen", or "offen", or show a green

square. The mirror system hypothesis summarised earlier accounts for this through the grounding of language in communicative situations. As the shop sign example shows, language is embedded in a context, often one that allows thinking beyond the here and now (the shop is open at this moment when the sign is visible but will cease to be open at some point in the future).

The capacity of languages to extend cognition is evident in abstract concepts. Abstract concepts, by definition, cannot be touched, seen, tasted, heard, or smelled, and yet we have words for "freedom", "guilt", and "angular momentum", which allow these concepts to be communicated. When communicating abstract ideas, individuals typically use concrete situations or examples (Barsalou & Wiemer-Hastings, 2005). Some of these may, quite literally, involve the body. For instance, when talking about "angular momentum", a speaker may shape their hand to form a particular angle and then move it. Teachers who pay attention to their use of such gestures can communicate mathematical concepts more easily, and encouraging pupils to do the same improves learning (e.g., Nathan, 2022, pp. 66–8). Combining mathematics education—especially geometry, fractions, and symmetry—with dance has proven effective (Senior, 2016). In addition to thinking about how bodily movements might be used to improve education on seemingly abstract topics, 4E research into human languages has revealed a great deal about how abstract concepts are formed, as well as how they are processed and communicated.

Language in use: Conceptual metaphors and categorisation systems

Markus Kiefer and Natalie Trumpp (2012) reject the dichotomy between concrete and abstract concepts to argue that "abstract concepts are embedded into concrete situations that express the content of the abstract concept" (p. 19). One of their examples is "guilt", a concept experienced in the body as an emotional state. Guilt is described as "weighing a person down", as having a "load" on our shoulders. The internal experience of guilt is experienced and communicated through concrete analogies. As such, languages are neither entirely symbolic nor fully arbitrary because they are grounded in the body.

The grounding of language in the body has been extensively investigated in relation to conceptual metaphors. A conceptual metaphor (or "cognitive metaphor") refers to the understanding of a concept through analogy to something from another domain. One of Saussure's (1916/2011, pp. 88–9) classic metaphors describes language in terms of chess (see also Geeraerts, 2009, pp. 48–50). Chess pieces are symbolic: We cannot determine the rules of play from observing the pieces. Even when we know the rules, the behaviours of each piece are determined by the context of other pieces. For language, "each linguistic term derives its value from its opposition to all the other terms", and "the system is always momentary; it varies from one position to the next" (Saussure, 1916/2011, p. 89). This metaphor makes the limited nature of arbitrariness accessible: Each chess piece can only move in a restricted number

of ways. However, we should also note how the metaphor fails: The aim of chess is to beat one's opponent. The aims of language production are decidedly more varied.

The chess metaphor draws attention to itself as an artificial comparison. However, most embodied metaphors are so naturalised, we do not even notice that they are metaphors. For example, nine-tenths of the population is right-handed, and so the word that means "right" also means "correct" in many languages. In contrast, "left" is often associated with somewhat negative ideas (e.g., "left over", "left out"). Research into extended metaphors by, most notably, George Lakoff and Mark Johnson (1980) indicates that language draws heavily on bodily experiences to conceptualise abstract ideas. As Lakoff explains, "[R]eason has a bodily basis" (1987, p. xi). Claims building on this line of enquiry are fundamentally experiential (for an overview, see Haser, 2005, pp. 4–7). The underlying idea is that humans imaginatively exploit the knowledge they gain from bodily experiences to conceptualise abstract ideas. For instance, the decimal system is an abstraction based on the physiology of the digits on our hands. In cognitive linguistics, attention is drawn less to the decimal system and more towards the use of the term "digit" to refer to both a number and to a finger or thumb. These conflations—metaphors—provide lines of enquiry into *how* we think.

As indicated by the title of Lakoff's *Women, Fire, and Dangerous Things: What Categories Reveal About the Mind* (1987), all forms of categorisation (not only metaphor and metonymy) provide insight into how ideas are processed. This is sometimes referred to as "prototype theory", which recognises that some items within any given category are central, while others are borderline. For example, "apple" is a prototypical example of the category "fruit", but "tomato" lies on the border between "fruit" and "vegetable". Note how both "fruit" and "vegetable" are defined by experiences of eating. Nuts and mushrooms are also edible and produced for the same purposes as apples, but we tend not to think of them as prototypical examples of either fruit or vegetables. "Toadstools" are distinguished from "mushrooms" primarily on the basis of the human digestive system, not the features of the fungi. Moreover, Lakoff observes how rapidly the human mind endeavours to produce classifications. The title of his book appears to have a random list of words—women, fire, and dangerous things—but we read the list as suggesting that these items have something in common: "the chain of inference—from conjunction to categorisation to commonality—is the norm" (Lakoff, 1987, p. 5). Later, he discusses Dyirbal (an Aboriginal Australian language) which does have a category that combines these things: "balan" (pp. 92–104). As fascinating as his discussion of Dyirbal is, the important point in terms of understanding how language is grounded in the body is not that this is a category that exists in a natural language but rather the rapid chain of inference among non-Dyirbal speakers. Simply placing the words in a list causes us to seek commonalities and conclude that the speaker considers women to be fiery and dangerous.

Lakoff notes that although many of our categories appear to be based on the things that are being classified, "a large proportion of our categories are not categories of *things*; they are categories of abstract entities" such as the palatability of mushrooms and toadstools (1987, p. 6). If we accept that our categories do indeed reveal how the mind works, the importance of political correctness in speech becomes more urgent. Take, for example, the widespread metaphor that LIGHT IS GOOD and DARK IS BAD (e.g., "Her face lit up" vs "I was in a dark place"). Humans have poor night vision, and so darkness is a time of elevated risk. Thus the metaphor appears to be driven by relevant, real human experiences. However, the categorisation system of the mind can also affect how we interpret what we see. Studies of visual perception demonstrate that what we see is determined by our mindset (Balcetis, 2006; Balcetis & Lassiter, 2010). So while LIGHT IS GOOD and DARK IS BAD may make sense in relation to daylight, the extension of the metaphor into other areas can be problematic. For instance, describing a person as "fair" could either mean that they are honest or that they have light-coloured hair. Language affects what we pay attention to.

The experiential approach to understanding how metaphors function has been challenged by, amongst others, Verena Haser (2005). One of her concerns is that Lakoff and Johnson's ideas can be falsified by evidence, such as the existence of competing metaphors. For instance, she challenges the metaphor THEORIES ARE BUILDINGS by noting that one can refer to a key proponent of the theory as a "father" or as "fathering" the theory (Haser, 2005, pp. 216–24). Haser is correct in her assertion that all metaphors break down. A theory is not actually a building; light (or its absence) has no moral value; chess and language are not the same. Cognitive linguists following Lakoff and Johnson do not suggest that metaphors are fixed; they simply highlight the tendency to use bodily experiences to communicate abstract ideas.

Haser's critique is most valuable in her call for empirical evidence that might allow the hypotheses to be falsified. Raymond Gibbs and his colleagues have found innovative ways to provide such evidence. As they explain,

> Empirical research is needed to establish connections between embodiment and metaphor in thought and language. Only by explicitly attempting to find how patterns of embodied experience relate to metaphoric thought and language, and doing this in a way that a hypothesis can, in principle, be falsified, can a strong case be made for, or against, embodied metaphor. … Yet there is a large amount of empirical evidence from linguistics and psychology that demonstrates how metaphor gains much of its conceptual and expressive power from the systematic mappings of embodied source domains onto more abstract target domains of experience.
>
> (Gibbs et al., 2004, p. 1207)

Empirical evidence of the kind Gibbs et al. and Haser call for has been provided by Madalina Bucur and Costanza Papagno (2021). They produced a meta-analysis of 32 studies using brain activation imaging to investigate whether different parts of the brain were used to process abstract and concrete concepts. Their study deliberately excluded literal and figurative sentences, and focused exclusively on the data related to single words (verbs and nouns). Their cluster analyses of the areas activated in response to individual words demonstrate at least partially segregated brain areas for concrete or abstract processing; this segregation was strongest for nouns. This was surprising because so much of language combines the concrete with the abstract. For instance, the words "chair", "tree", and "ball" appear to be concrete, but they can also be used in an abstract sense: "chairing a meeting", "tree diagram", and "having a ball".

Bucur and Papagno removed literal and figurative sentences from the data, which may explain their findings. Accounts of how polysemous words and metaphorical language are processed are needed. For instance, Raposo et al. (2009) found clear neurological differences in the processing of "kick the ball" and "kick the bucket": Processing the former indicated activation in the sensorimotor system, whereas processing the latter did not. Their example is particularly interesting in that it is perfectly possible to kick a bucket. The idiom originates from kicking a bucket under a condemned man on the gallows, thereby causing him to hang from the noose. However, the phrase is more commonly used today as a coarse way to describe a person's death, and thus "kicking" in this context has little to do with the actions of the feet, with the result that the brain activation in response to the phrase does not stimulate the sensorimotor system.

Implications for education

Studies of how languages emerged and how children learn languages emphasise the role of the whole body in meaning-making through language. The main takeaway from this for both L1 and L2 language education is that separating words and grammatical forms from their embedded, enacted contexts lowers children's chances of success. When a caretaker reads a book to a child, they will adjust their reading to the child's responses, enacting through their voice, touch, and gaze while the book provides additional visual support. When the level of enactment is lowered—for instance, when listening to a recording of a book—the quality of the communication is lowered. The challenge for language teachers, especially L2 teachers who must model a language culture that is not their own, is to find ways to impart as much of the additional information as possible.

The second takeaway from evolutionary accounts of language learning relates to the way maturation reduces the enabling conditions for language learning. Infants rapidly learn to focus their attention on salient aspects of the language in their surroundings and dismiss what Arbib refers to as "ignorable

details" (2012, p. 291). As a result, by the time children start school, their perception skills have already narrowed, and this process continues through to puberty. Post-pubertal learners find it very difficult to perceive aspects of a language that are salient in the target language but not in the speakers' L1. On a policy level, this finding supports plans for the early introduction of L2 education. On an individual level, teachers will need to focus on exercises that help learners perceive those aspects of the language that are only salient in the target language.

The research on how abstract language is grounded in the body also has implications for education. Metaphors and categorisation practices reveal that abstract ideas are deeply grounded in our experiences of the world through the senses. Using gestures that draw on these connections (e.g., shaping the hands to form angles when teaching mathematics) helps children learn more efficiently, and for children to learn to make such bodily connections themselves is even more effective (Nathan, 2022).

Research that starts at the other end—investigating language—indicates that although words may be stored differently, accessing and using language inevitably leads to more complex scenarios in which the sensorimotor system is involved in meaning-making. The willingness of humans to seek connections between seemingly disparate concepts (such as women, fire, and dangerous things) when they are presented as a list can be used to promote imaginative, critical thinking but may inadvertently lead people to form inappropriate connections. Both these findings are important for textbook designers and teachers planning classroom activities.

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3 Exploring reading aloud events through embodied learning

Impacts on early literacy

Theresa Schilhab, Gitte Balling, and Gertrud Lynge Esbensen

Introductory scene

Preschoolers are seated in a half circle around an adult in a corner of the room decorated to support ear and eye contact. It is filled with soft, coloured pillows to cosy up against and invite relaxed moments. The teacher is about to read aloud a story about a young frog doing cheeky things like colouring books without permission and bathing the mobile phone because it is dirty. The children know that once they are seated, the teacher reads and points to illustrations and asks them questions relating to the text. The teacher has arranged for colleagues to take care of those children who declined to participate. The teacher looks forward to the story, conversations, and various associations offered by the children. When they reach the crux of the story—the use of crayons in forbidden places—one child will definitely talk about her little brother entering her room without permission, another about her last drawing and why she likes water colouring, and a third will share thoughts about a snake taking the place of the frog and being just as cheeky.

The teacher enjoys reading to the children and knows the story by heart. She modulates her voice according to the storyline. She has practised her sassy tone when speaking as the frog, and the children are thrilled. Her voice deepens when she impersonates the story's stressed schoolteacher who tries to save the book from the frog's colour attack. After the reading-aloud session, the children repeat selected sentences and speak about being sassy and how funny it is that the teacher's hair stands up straight in the air when he shouts and scolds the frog for misbehaving.

Introduction

The embodied cognition approach assumes that competent language use in conversations and reading emerges from first-person experiences with real phenomena (e.g., Pulvermüller, 2005). Accordingly, the language competencies at play when we—for example—exchange words with others, talk to

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ourselves, and read on our own originate from lived experiences (Klomberg et al., 2022).

Following this line of thinking, throughout life, we attribute meaning to utterances, conversations, and texts based on previous and current experiences. These experiences are characterised by situated learning in social and physical contexts that involve meaningful verbal and non-verbal actions and interactions (Kontra et al., 2012). Since experiential processes dominate competent language use, we are urged to re-conceptualise which didactic tools to select when teaching pupils to read.

Following the embodied cognition approach, when pupils learn to read, their experiences become important in two distinct dimensions: (1) as part of the physicality of the reading process that is, where we are, what we do, and how we feel when we read and (2) as part of attributing meaning to the text (Mangen & Schilhab, 2012; Schilhab et al., 2018). We advocate that we can illuminate both dimensions if we consider reading to be embodied, enacted, embedded, and extended—the 4Es (see also, Kravchenko, 2021).

Both dimensions—i.e., the physicality and the meaningfulness of reading—are to some extent recognised by contemporary reading research on pre-literacy reading. In the last four decades, reading researchers have studied the significance of reading aloud events for early literacy development (e.g., Altwerger et al., 1985; Ninio & Bruner, 1976). Studies of reading aloud, shared reading, and other forms of literacy events show that these types of events are largely social and cultural and take meaning from their environment. In this sense, they underline that learning to read is highly situated.

Books and shared reading are of significant importance for the development of reading comprehension and vocabulary as books present a wider vocabulary than experienced in ordinary conversations (Mol et al., 2008). Reading aloud events are not about giving a precise reading of a specific book but rather stimulating the child to participate and interact in the practice. The book-sharing dialogue includes asking open-ended questions and encouraging the child to participate. By involving the child, the adult can combine the labelling of objects in the book with the child's own life experiences, creating a more personal context for comprehension. During reading, the adult is able to fine-tune the conversation, adding the information the child needs to create a meaningful understanding of the text. As the child develops a more complex understanding and vocabulary, the adult begins to pay more attention to the text and through emphases and pauses invites the child to join in the reading. Recent research points at reading aloud as an event that involves not only words and sounds but also rhythms, rhymes, and gestures, which engage the bodies of both reader and child (Hedemark & Lindberg, 2018). Thus, the act of reading is an embodied event where literacy practice becomes inscribed in the body of the child.

Whereas contemporary reading research acknowledges that learning to read can be viewed as a social practice, aspects like embodiment, enactment, and extendedness seem less well understood. Moreover, the social practice

position under-describes how children change from attributing meaning in lived practices to creating imaginary universes based on texts.

In this chapter, we detail the situatedness of reading-aloud events to show how 4E aspects inform reading-aloud practices. We argue that the 4E framework provides powerful tools to understand how reading aloud may facilitate a child's leap from focusing on concrete objects in the environment to objects of their minds. We present a model for five central domains that emerge when we frame a reading-aloud event using a 4E understanding. The model serves to explicate and demonstrate the embodied depth of a reading-aloud situation and condenses the insight gained from 4E into a tool that can assist pedagogical choices.

From online to offline meaning attribution

According to 4E studies on language acquisition, when toddlers initially learn to master the referential aspect of language—e.g., that the notion "apple" refers to an edible fruit—the phenomena or items referred to by concepts are often at the centre of practices and conversations (Pulvermüller, 2005). For example, infants and toddlers learn how to verbally greet others—e.g., parents, siblings, friends, or strangers—as part of an elaborate greeting practice that imbues the verbal act with meaning (Wehberg et al., 2007).

Hence, listening to the word "greeting" includes senso-motoric processes associated with the typical greeting practice (Barsalou, 2009). These might be the sight of family members wearing overcoats, carrying umbrellas, holding car keys, or entering the hall; the sound of opening and closing the door; phrases like "bye" and the interoceptive feeling of waving and smiling. During acquisition, the mental processes are thus "online", which signifies that the meaning-making is distributed across individuals, items, and the environment in the now and therefore involves co-processing of the environment, perceptual activity, enactment, and so on (Wilson, 2002).

Later, children also master linguistic referencing and understand "greeting" without the simultaneous experience of concurrent greeting practices. A friend may refer to a meeting with another friend in conversation, and a teacher may refer to the "cultural meeting" between immigrants and indigenous peoples in a historical context. In such cases, the processes sustaining the mentalising are "offline" since meaning-making processes rely more on remembrance and less on momentary perception and interactions with the environment (Klomberg et al., 2022).

The 4E approach suggests that these offline linguistic processes involve imagining activities. Hence, understanding the sentence "the ranger saw an eagle in its nest" depends on the *simulation* of the lived practices in which this sentence would make sense (Zwaan et al., 2002). However, bringing forth explicit memories and feelings of what is the case when using words like "greeting" tax executive functions (e.g., Diamond, 2013). These functions are necessary for building and sustaining the offline imagining and for inhibiting

interfering thoughts or stimulations that would distract. Adequate executive function activity has been found to correlate with improved learning and life satisfaction and can be exercised in learning environments that stimulate children's capacities for imagery and concentration (Diamond & Ling, 2016). Rich experiences with simulating are crucial for proficient readers since reading depends on the creation of "situation models"—mental representations created by the reader of the setting or events described in a text (Therriault & Rinck, 2007).

In the following section, we discuss the reading-aloud event described in the introductory scene. As part of the session, the adult reader demonstrates the reading practice, creates meaningful reading sessions, poses as a role model, and sustains the early readers' exploration of the cognitive challenge of offline meaning-making. In other words, the modelled reading-aloud event articulates and conceptualises the different embodied aspects which pertain to online and offline linguistic practices. Therefore, the model can be used to obtain an overview of how each of the domains is thought to contribute to early literacy and which should be pursued in an actual reading-aloud session.

Reading aloud in light of the 4Es

An ideal reading-aloud event can be described in terms of five domains informed by the 4Es. These domains constitute embodied practices in which perceiving bodies that interact with the social and material dimensions of the event mix online and offline processing when they participate. The domains are labelled *social embeddedness*, *physical embeddedness*, *materiality and meaning of language*, *joint space*, and *cognitive processes.* Figure 3.1 presents the model for reading aloud that we have developed based on the 4E perspective (see also Schilhab, 2023a, 2023b).

The five domains are all under the influence of the 4E aspects. While some 4E aspects may be more relevant in characterising one domain than another, all domains contain mixed elements of embeddedness, extendedness, enactment, and embodiment. The interrelated nature of the domains may make it difficult to tease out in actual reading events; however, articulation and analysis will assist in identifying which domains preschool teachers who read aloud are employing or could potentially endorse.

First domain: Social embeddedness

Children are highly susceptible to both their social and physical environments. Building on Vygotsky, the anthropologist Hasse develops the concept "social designation" to identify processes where more experienced peers identify and teach children cultural meaning in everyday life: verbally and with body signs and actions (Hasse, 2015). When readers handle a book as part of the reading process, they simultaneously demonstrate the value attributed to books and reading. This applies to the entire reading situation and connects to the

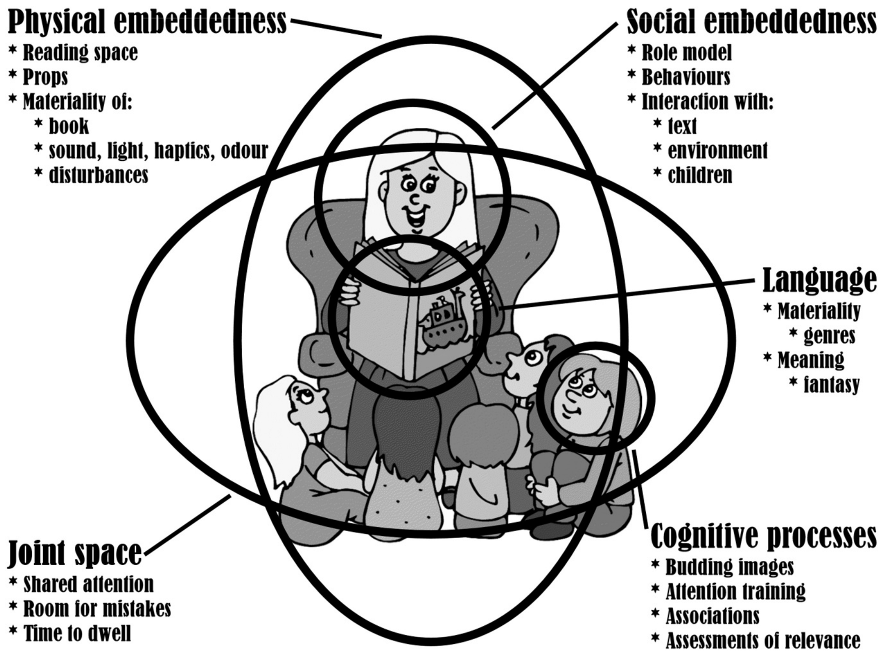

Figure 3.1 An ideal reading-aloud event can be described in terms of five domains informed by the 4Es. The domains are labelled *social embeddedness*, *physical embeddedness*, *materiality and meaning of language*, *joint space*, and *cognitive processes.*

reader's status as a role model. It matters whether they are seated in a comfortable chair, dwell on particular words and illustrations, prioritise the reading above other tasks, and so on. It matters that the reader invites children to a reading event as a particular and socially significant activity. The reader's mindset and actions demonstrate that reading is an important and distinctive activity determined by particular routines and embraced with particular care and concentration. The embodied activity of the reading adult can be imitated in ways similar to how they act in an eating situation, sleeping situation, play situation, and greeting situation.

The reader's actions in relation to the text have similar meaning-making connotations. The reader might, for example, signify the meaning of the words and sentences by modulating their voice in accordance with the content, lingering on or displaying interest in certain expressions, and pausing in selected places to provide the listener with time to dwell on and absorb the situation.

Second domain: Physical embeddedness

The actions of the role model and the reading situation also occupy a physical space with included objects. The reading platform might be a

book with or without illustrations, a fold-out book with pop-up cardboard figures, or a tablet or phone with an app including technology-based and multimodal functions.

The surroundings might be a secluded room with dim lights and no windows. It can take the form of a circle on the floor with sack pillows or a bed or sofa with velvety pillows. Cake and juice might be served, or eating is prohibited. The reader might also include puppets or other props, be dressed spectacularly, decorate the room with candles or tree branches, or play classical music or birdsong as an ambient soundscape.

Thus, the materiality of the physical space can be used to support the content of the text and the reading event through staging and externalisation of the associations and internal movements stirred up by the entire situation (e.g., Glenberg, 2008). In these instances, the physical embeddedness also works to extend the mind as material points for memorisation processes.

Third domain: The materiality and meaning of language

In a reading-aloud event, language appears both as a material object that can be perceived through the senses and that which gives rise to meaning. The former refers to the size of vocabulary and how the sounds relate to the alphabet and written words, as well as what can be said grammatically or not. Authors are expert writers, so part of the reading-aloud experience is exposing children to original ways of stringing words and sentences together. The material dimension of language is also about rhyme and rhythm. For example, a child may learn that texts differ from ordinary speech by, for example, belonging to a certain genre. The listener, therefore, becomes familiar with different narrative structures such as fairy tales, horror stories, fables, and so on.

The other aspect of language learning is meaning, where the focus is on what the words correspond to in the world. A child may learn that language designates “worlds” that do not necessarily exist: stories about counterfactual realities and of cheeky frogs who draw, and stories like Alice in Wonderland, which do not follow real-world logic but follow rules nevertheless.

Language as meaning can be used to open up insights into the imaginary worlds of others. Through the world of the naughty frog, a child becomes familiar with how it feels to be cheeky and what consequences it might entail.

Fourth domain: Joint space

In a reading situation, a shared experience is established around a common third (e.g., Ruch et al., 2017) constituted by the adult’s voice acting, illustrations, the children’s attention, and the conversations elicited. The experience gravitates around the presence of the reader and their practices and props, and the invested minds of the children. They meet in joint attention when the reader slowly orchestrates the unfolding of the story while meeting their gaze. The reader’s glance alternates between the pages they read and eye contact

with their listeners. Within this room of joint attention, a safe space arises: joy, thrills, laughs, misunderstandings, associations, intuitions, and feelings are welcome. The space is characterised by following a time of its own. The nooks and crannies of the children's minds are stirred up by the entire setting, and the reader's care for premature ideas and associations can be viewed as a playground for imagining what is read. Here, the adult must behave calmly and assertively, acknowledging ideas that pop up and inviting a meaning negotiation; these occurrences may signify the very first step to interpreting story worlds.

Ideally, the children ask questions, present ideas, and associate with previous experiences or fragments they have heard. They are supported in practising the use of language understandably and competently. They explore what mental acts are needed to access relevant experiences, memories, and associations. Within the joint attention dimension, children learn culturally approved ways of placing their bodies when adults read to them and how and when it is accepted to speak during the activity. This learning process begins while the toddler sits on a caregiver's lap or stands beside the caregiver while they explore a picture book together.

Fifth domain: Cognitive processes

The joint space exists as the sensation of meeting and being met by others in a world that is ethereal and fragile—but real. It may be carried by the cushioned interior, the bodily manifestations, the practices and pitch height of peers, and the spirited presence of everyone in the room. But it takes a particular form characterised by the willingness of the adult and children to enter an imaginary world ignited by the author's narrative.

In this space, there is room for practising finding "relevant" associations and formulating them so that they appear relevant. However, these actions have a mental side, which can be more or less guided by the reader. Through the joint space, the child is provided the opportunity to "taste" ideas that seem intuitively relevant, why they feel relevant, how to transform an intuitive feeling into words shared by others, and so on. The child is also guided to reject associations and sensations as irrelevant when the narrator appears as a qualifying "soundboard" when either actively reinforcing or downplaying the child's responses.

This dimension is described in part by the concept of "derived embodiment" introduced by Schilhab (e.g., 2011, 2015, 2017). Derived embodiment occurs when language users, through linguistic exchanges with knowledgeable peers, acquire abstract ideas and knowledge about phenomena and occurrences they have no first-hand experience with. It is through the spectator/respondent dyad that learners *practise* how to *access*, *create*, and *reenact* appropriate imaginings. As Schilhab argued, these quite delicate mental activities rely heavily on social interactions in which peers help endorse, shape, and cultivate the learner's imaginative creations through joint attention processes.

Constraints and qualities of the event

Many of the dimensions of a reading-aloud event—such as increasing vocabulary, learning turn-taking, and being guided to reflect on particular experiences—are associated with other activities, for example, ordinary conversations. So, what makes a reading-aloud event special and didactically important?

Firstly, not all reading-aloud events are productive in the sense discussed here, which is why we operate with an "ideal reading-aloud event". Its success depends on access to a quiet space, a teacher who is comfortable with reading and performing in front of children, the quality of the narrative, as well as how familiar children are with being read to. According to Gulløv (2014, p. 32),

> Children who are used to looking at books and having stories read aloud to them are more eager to participate when staff members begin to read to the group. Children not trained to listen often lose interest and will soon leave the activity, looking for more engaging things to do. They prefer to play with children who, like themselves, have no at-home experiences with reading.

Nevertheless, we argue that in the ideal situation, the space established by the teacher and the children has its very own qualities not found in other "joint attention" spaces. Compare, for example, joint attention involved in a "put-on-the raincoat-because-we-have-to-go-out" situation. The focus here is for the child to find the rainwear and get dressed in the right way within a reasonable time so that the waiting time for others is minimised. In the reading-aloud space, there is time and space for associations, i.e., thoughts and wild inventions that can be tested on the adult. Often, the narrative has certain material qualities—the story is set in otherworldly places and follows an untypical logic, which affords linguistic exchanges that challenge children to fantasise and explore their experiences, intuitions, and thoughts. Such journeys are seldom welcome at the table, under transport, when learning to swim or doing homework.

Thus, a reading-aloud event with its joint attention focus is particularly useful for cultivating children's executive functions and abilities to grasp meanings without concrete objects.

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4 Inclusive language teaching

Pauline von Bonsdorff and Aila Marjomäki

Introduction

This chapter explores how language learning in primary school can be enhanced through an approach that affirms the embodied, enactive, embedded, and extended character of language. Here, "language learning" refers not just to learning a new language or expanding one's command of grammar and vocabulary in any language but to the ongoing process of developing, elaborating, and refining language as a personal means of expression. We believe a holistic, multimodal mode is the default mode of children's spontaneous communication and adult communication alike. Humans communicate out of a fundamental desire to share and explore. We speak because we have something to say and want to make contact and because we are curious.

While language is an instrument for thought and communication, it is also more: a structure that supports us, an environment we inhabit (Merleau-Ponty, 1945/1992, 1969/1995a, 2001; von Bonsdorff, 2015). Moreover, language is not the same as thinking, nor does it provide transparent access to thought. While language provides rich opportunities for expression and communication, it also offers resistance. From this perspective, marks of hesitation, fragmented sentences, breaking rules of grammar, or introducing new, non-normative expressions can be seen as meaningful communicative gestures rather than failures or faults.

Through examples from a Finnish primary school, we shall discuss what a holistic 4E approach can mean in practices of teaching and learning language. This approach is important when working with children and youth because the formation and transformation of self and world through communication are especially pertinent in this period of life. From a platform of phenomenological philosophy and 4E research, we present ways of implementing the 4E principles "embodied, enactive, embedded, and extended" in educational contexts with young people.

We combine philosophical and theoretical perspectives with insights from the classroom. While Pauline von Bonsdorff carries the main responsibility for theory, practice is provided by Aila Marjomäki, who worked as a teacher in special education from 1987 to 2019 with research breaks during 2006–10.

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That said, we have influenced each other's thinking through conversations over the years, not least in the research project Spaces for Children (Academy of Finland, 2007–10). After her research break, Marjomäki revised her teaching and developed new methods with teacher colleagues, described in the section titled "Explorations". Our understanding of how a 4E approach can be implemented thus stems importantly from a participatory, dialogic, action research perspective. This leads to a grounded view of how the 4E principles can contribute to school, not just in teaching and learning but also in supporting personal growth in the school community.

Exposition

Here, we present some starting points for a 4E approach to teaching language in schools. We use Maurice Merleau-Ponty's (1908–61) philosophy of language as a backbone, complemented with more recent research. In our view, this contributes to a deeper understanding of the 4Es, their interrelations, and implications for teaching and learning language.

Merleau-Ponty, best known for his philosophy of perception and embodiment, is often mentioned in theories of embodied cognition and learning. His philosophy of language, although an integral part of his thinking, is less well known. Much of it was only posthumously published (e.g., Merleau-Ponty, 1969/1995a). Merleau-Ponty discussed language in his philosophy of perception (1945/1992) and in reflections on the individual style of philosophers and authors, and explored language as co-constituting structures and styles of being (1966, 1964/1995b, 2001, p. 65). In addition, he was interested in language acquisition and emphasised the continuity between early non-verbal vocalisations and verbal expressions, pointing out that vocal communicative intentions exist before words (2001, 18–9).

As a first starting point for 4E approaches, language is *extended*. Following Merleau-Ponty, language is a structure of the world as we experience it (the lifeworld), which is formed through cultural practices, knowledge, and belief systems. The relationship between persons, their lifeworlds, and language is intimate and inseparable while also dynamic. Our mother tongue is especially and inextricably part of what we are rather than just a possession, e.g., a sign system, that we use. Moreover, although experiences can be primarily visual, musical, kinaesthetic, emotional, etc., rather than linguistic, we share and communicate them through language, either as such or to complement other media. In that sense, language reaches everywhere and can map our whole world, while that world cannot be reduced to language only. Hence, language is always already an extended system involved in all forms of knowing and communicating. At the same time, it is not the only means of coming to know but operates alongside others.

Next, language is both *embodied* and *enactive*. Following Merleau-Ponty, these aspects are intimately connected. He emphasises that language, like perception, is dynamic and based in our innate desire to act, explore, and

communicate (cf. Trevarthen, 2001). More than an instrument, and like the body, language is a capacity for action (von Bonsdorff, 2015, p. 107). Consequently, for Merleau-Ponty, language is primarily speech or utterances (*parole*), whether spoken or written, and only secondarily a fixed system of signs and grammar (*langue*). The primacy of speech and the will to communicate is connected to how an infant learns its mother tongue: initially a soundscape with expressive form which gradually, through interactions, becomes structured and internalised as language (Merleau-Ponty, 2001, pp. 17–22). As we indicate in this chapter, an approach that affirms and builds on the desire to communicate is fruitful in the school context.

In Merleau-Ponty, the embodied and enactive character of language is intrinsically tied to its expressive dimension, to the desire to say something and find the right expression. This is about personal intentions rather than correct language and about language as *mine*, my utterances (*parole*), not language as a general system (*langue*). It is precisely in the effort to express something personal and specific that meaning is born, and a self simultaneously articulated (cf. von Bonsdorff, 2015, p. 108). Yet expression for Merleau-Ponty does not come from a supposed "inner" self but is, rather, a modulation of the medium (language) and of the speaker: "a modulation simultaneously of the world and of our existence" (Merleau-Ponty, 1945/1992, p. 214, 1969/1995a, 2011; von Bonsdorff, 2015, p. 103).

The effort to speak is connected to gesture on many levels. "The spoken word is a real gesture, and it has meaning of its own, just as gesture has", writes Merleau-Ponty (1945/1992, p. 214). Words are part of our "phonetic gesticulation" in seeking the right expression—a gesticulation that reaches towards memory and imagination (von Bonsdorff, 2015, pp. 106–7; cf. Wittgenstein, 2009). In addition to speech as gesture, bodily gestures play a role in accompanying speech. David McNeill has shown the inseparability of hand movements and speech: gesture and speech are simultaneous and interdependent. Gesture "orchestrates" speech, being more than illustration: it helps the speaker articulate their ideas and find the right verbal expressions (McNeill, 2016). Merleau-Ponty points to the importance of the gestural dimension in shared situations: I participate "in a sort of blind recognition" that precedes interpretation (1945/1992, p. 216).

If there is a close relationship between embodied and enactive, as suggested, there is also one between *enactive* and *embedded*. For Merleau-Ponty, the body "opens me to the world and places me in a situation" (1945/1992, p. 192). Enactivists emphasise the social dimension of learning, including "participatory sense-making" (Dierckxsens & Bergmann, 2022, p. 300). This points to how any individual is part of—i.e., embedded in—groups. Similarly, linguistic meaning is grasped in shared situations and contexts of language use (Merleau-Ponty, 1945/1992, p. 209, 2001, pp. 36, 47, 53; cf. Engelland, 2014, Reddy, 2008 and Trevarthen, 2011). In bilingual families, embeddedness can be experienced concretely, as when my toddler son referred to "how Mummy speaks" and "how Daddy speaks" instead of saying "Swedish" and "Finnish".

The close relationship between one's group and language is also manifested in children's secret, sometimes clandestine, languages.

"*En*active" indicates a dynamic direction from the individual to the social and physical world and emphasises the creative character of action. When we speak, we are in a situation and participate in world-making through ongoing processes of change and transformation. In these processes, values are integrated. Dierckxsens and Bergmann (2022, p. 304) argue that ethics is "a process of responding to social affordances and participatory sense-making". Moreover, "ethical values and norms … are intertwined with how we feel our bodies in their surroundings". Yet this is not only the concrete here and now, for language is "extended into the social imaginary" (Dierckxsens & Bergmann, 2022, p. 307.)

Following Dierckxsens and Bergmann (2022, pp. 309–11), storytelling is crucial for the development of critical ethical learning because it provides possibilities for both distancing and participation—sharing with and being influenced by others. In a school context of language learning, storytelling represents a creative approach. The aesthetic and expressive dimension of language is fundamental also in Merleau-Ponty: in elaborations on style as a way of being and gesture as expressive and participatory; in pointing to the inherently hazardous character of language; in foregrounding the imagination and play-acting, we need to learn a language (2001, pp. 77, 29, 48). This implies playing with self-presentations and interpretations that can be accepted or rejected by others. Playful Learning has indeed been established as a concept both in Finland (plchelsinki.fi/) and Denmark (playful-learning.dk/english/). In the next section, we describe how these starting points can be implemented.

Explorations

We shall describe two courses of teaching Finnish, the Reading Circle, and the Reading Lamp, developed in a Finnish primary school through the cooperation of class teachers and a teacher of special education. Both courses are about developing reading and storytelling skills among peers by proceeding from speech to texts, affirming the primacy of expression and communication as outlined earlier. To understand the significance of these formats, a few words should be said about Finnish special education as it is practised in language teaching.

Normally, pupils are identified as in need of special education based on learning difficulties. These are measured using exact parameters, such as speed of reading, reading comprehension, and spelling. Special education is provided in small groups outside the normal classroom, focusing on identified problems. The aim is to help the pupil attain a minimum competence as defined by curricula. As a result, pupils become increasingly aware of their shortcomings. In the worst-case scenario, these even become defining features of personal identity, emphasising one's difference (being a "special child") as compared to peers.

Lately, inclusion has become more popular. Instead of separating pupils with special needs from the class, teaching is provided in class through teachers' cooperation, and observing pupils' individual needs. The Reading Circle and the Reading Lamp are examples of inclusion. Both courses ran for four to six weeks and were taught jointly by the class teacher and the teacher of special education, sometimes with the help of a school assistant. Three parallel classes from grades 1–6 participated (70–80 pupils per grade, aged 6–13). The groups included pupils from different ethnicities and/or recent experiences of immigration, as well as native pupils with learning challenges. Teaching was provided in the class (20–25 children, 2–3 adults) without separating pupils with special needs.

The Reading Circle (two to three weekly hours) started with a presentation of literary genres adjusted for children's age. Each child chose a genre that interested them, wrote it on a paper, and added their name on the other side. Consequently, groups were formed anonymously and based on personal taste. Groups first studied the genre on the city library's web page and then chose a book and checked its availability. While waiting for the book, they shared expectations based on title, cover, and blurb. They then set up a reading schedule. Before each meeting, everyone prepared three questions based on their reading. In weekly roundtable meetings, groups discussed their readings while drawing characters, places, events, and details from the story on a Reading Circle Cloth (see Figure 4.1). Each child had their own area of the cloth, sometimes joining with another pupil. The aim was not to create a unified picture, and artistic quality was irrelevant. The teachers circulated in the room but did not interfere with the groups. In another weekly meeting, groups prepared a PowerPoint presentation on the author, plot, events, and characters of the book for the Literature Conference that ended the course (in the final year, this was replaced with a Book Fair where sixth graders gave reading tips for grades 4 and 5). The atmosphere at these events was excited and attentive. Sometimes groups brought food servings typical for the book from home or an object related to the story.

Stimulating curiosity and imagination and facilitating storytelling on pupils' terms were the aims of the second course, the Reading Lamp (two weekly hours). Based on an introduction by the teacher, often including image, sound, movement, drama, or objects, pupils wrote words in their booklets. They then chose one word to share with the others, which could be a word already mentioned. This made it easier to participate. A detail of the introduction was then picked, and children were asked to write about it, allowing their minds to flow freely. The idea was to create materials for the story. Next, they shared one sentence. In the lower grades, stories were usually finished in class, sometimes through a compilation of children's sentences, whereas older children created individual stories and could continue at home. Each writing process ended with a reading event. The venue was a windowless room, where chairs formed a half circle around an armchair and a table with pupils' booklets and a lamp. Upon entering, the only light was from the corridor. When everyone was seated, the lamp was lit, and children read their stories in random order, according to how the booklets happened to lay on the table. No one had to read, and they could ask a friend or an adult to do it for them. After each

Figure 4.1 Reading Circle Cloth drawn by a group of second-grade pupils (8 years old). Photograph by Heikki Hanka.

reading, there was time for questions and comments. Teachers neither read nor corrected the booklets and provided help only when asked to. While sharing words, sentences, and stories created collective experiences in an atmosphere of freedom and respect, sharing was not compulsory. On the one hand, children were allowed to borrow from each other; on the other, they were the owners of their narratives. They could change their stories while reading: animate, specify, add details, or skip unnecessary parts.

The courses shared certain pedagogical and design principles. Both had a recognisable structure. As annually recurring creative practices with articulated form, they became familiar to the pupils who eagerly expected next year's course, as shown by questionnaires about their willingness to participate in a similar course again. The structure comprised themes and variations, prepared parts and improvisations, starting points, and closures. This provided a clear yet varied rhythm. Both courses started with stimulating curiosity and imagination, continued with variations between individual work and sharing experiences, and ended with performative events. Learning environments were adapted to the activity at hand: The courses spread in the school building beyond the classroom. As the role of the teachers changed, so did power relations. The special education teacher was no longer a personal trainer for children with problems but worked holistically and with every child. Language challenges were treated as technical problems that could be solved. The Reading Lamp accepted purely oral storytelling: booklets were not read by teachers except on request. In the Reading Circle, parents or teachers could help pupils by reading for them.

Discussion

Our observations and insights are based on an experienced special education teacher's work during six academic years. They indicate what a holistic 4E approach can yield in terms of learning and growth when applied consistently. We now pinpoint some principles and outcomes of the courses, and how they relate to the 4E. We foreground aesthetic, playful, and expressive ingredients because they prompted spontaneous, self-motivated aesthetic agency (von Bonsdorff, 2018) in pupils performing as experts and narrators, thereby strengthening linguistic competencies. The children's ownership of the process, in planning, steering, and presenting their group work, and in crafting and narrating their individual stories granted them genuine authorship and created mutual recognition. Thus, the courses' outcomes include ethics and personal growth.

Children spontaneously adapted their language to context, realising and practising its *embeddedness*. While drawing, chatting was colloquial, with incomplete sentences and exclamations—i.e., verbal gestures—complemented with visual means and *bodily* gestures—i.e., "she was dressed like *this*". Yet in the conference, they used complete sentences and accurate vocabulary, taking the role of experts. It was also here that bodily gestures were most prominent, possibly a sign of belonging in the world of literature. Presenters were confident in the situation and dared to articulate interpretations and insights in the moment before an audience, *enacting* their role as conference speakers while manifesting how engaged thinking goes hand-in-hand with gesturing.

Teaching and learning were *extended* in the school far beyond the classroom, adding to pupils' engagement and *embedding* learning in memorable ways. In the Reading Lamp, the performative *enactment* was being a storyteller. The audience sat in the dark and listened to a voice from the direction of the light. The shared, attentive listening created an intimate and safe atmosphere. Children with reading or writing challenges could be recognised as brilliant narrators—not despite but irrespective of challenges. When teachers and children were no longer identified through problems, a space opened for being oneself with others in manifold ways.

Pupils were recognised as readers, writers, and storytellers with individual interests instead of being subject to assessments according to predefined criteria. Their interest in reading and writing grew with their will to share interpretations and stories with peers. Drawing facilitated the exchange of impressions and interpretations as pupils gave visual form to them, multimodally exploring and adding to the world of the work. Facing each other rather than a teacher supported equality and dialogue: children listened with curiosity and attention to each other, accepting disagreements and showing the fundamental *enactive* force of communication. This again proved the arts as a fruitful arena for civilised disagreement (von Bonsdorff, 2013). *Embedded* and *extended*, literary discussions spread to informal situations in school. There were cascades of new ideas and interests, such as reading the rest of a book series or writing a novel or a sequel to a story. The understanding of relationships between storytelling in different media, such as film, theatre, dance, etc., increased.

Ethical growth and learning concerned teachers as well as pupils. The teachers' roles changed from directors or conductors to producers, facilitators, and co-readers (they, too, read the books chosen by pupils). To give up authority and share responsibility with pupils required courage and flexibility. The diminished role of adults was graciously compensated by children taking on more responsibility. In the Reading Circle, they assessed the suitability of a book for their age group, perfectly capable of ethical deliberation without adult interference.

Conclusions

The courses showed how pedagogical formats that trust the capacity of pupils to self-organise within a given structure and to work individually and in groups might be conducive to learning outcomes that by far exceed the threshold separating the "special" and the "normal" child. Starting with the interests of children and trusting their will to explore and exchange can lead to unexpected, positive outcomes. This, however, demands that the teacher is willing to fully use their pedagogical skills and share responsibility with pupils. In regards to language learning, the courses affirm that oral storytelling vs the literate skills of reading and writing are different but that giving room for the former can nurture positive interest and development in the latter. This is especially the case if we allow the fundamental desire to communicate to proceed with hesitations, gestures, and multimodal practices of sharing and group feedback. Grammar and spelling must be taught in school, but they are not ends in themselves. Giving more space, and time, for children's creative and explorative language use fosters both learning and responsibility—learning that is for life rather than for school only.

Recommendations

If education aims at supporting the overall development of children, language teaching should include creative, experimental, playful, and open engagements with language, building on children's natural desire to share, interact, and communicate. We recommend that teachers engage seriously and creatively with the principles of the 4E approach and suggest the following principles:

Embodiment

Language is not just in the mind but in the whole body, and we express ourselves in many ways, including with verbal and embodied gestures. Play-acting, drawing, singing, and moving affirm this dimension and help articulate verbal meaning.

Enactivism

We speak because we want to address other people; we act with language. Mechanical drills are relatively pointless compared to doing something in and

with a peer group. There is no private language, and language as "mine" is always also "ours".

Embeddedness

Language is part of situations, and the more it is positively embedded in these, the deeper it touches and engages its learner. Pleasurable social experiences contribute to a sense of ownership and to identifying with the language as both "mine" and "ours".

Extension

Language is everywhere; it structures our world. Teaching that leaves the classroom can show this concretely.

Finally, we recommend teaching formats that give room for bottom-up rather than just top-down initiatives. For the teacher, reflectiveness, flexibility, and dialogue are important principles that can be implemented in many ways.

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Part III

Reading and writing in school

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5 Substrates, displays, technologies, and texts

Embodied, experiential reading

Sarah Bro Trasmundi and Anne Mangen

Introduction

If we think about it, reading is an awe-inspiring and, in a very literal sense, *unnatural* phenomenon: as humans, we were not born to read literary texts. Unlike for speaking, there is no genetic blueprint for reading, implying that our ability to learn to read letters and symbols had to be "painstakingly bolted on" to already existing brain circuitry (Dehaene, 2009). Leading neuroscientists explain our ability to read with reference to the neuronal recycling hypothesis (Dehaene, 2009) or the neural reuse hypothesis (Anderson, 2014; see also Trasmundi et al., 2021). Hence, reading is a cultural invention with enormous sociocultural implications. While reading is a cultural invention, it draws on both neuropsychological processes and embodied cognitive skills, all acquired through social practices. The impact of reading is remarkable: it enables us to access information and acquire knowledge beyond the local context; engage cognitively and emotionally in a range of types and genres of text; learn from and interact with other people, times, and cultures; expand and enrich our vocabulary and grasp of language(s); train our concentration and cultivate various modes of thinking; and participate in society.

Given what we know about the benefits of reading for cognitive and socio-emotional skills (for an overview, see Schüller-Zwierlein et al., 2022), the current changes in reading environments caused by increasing digitalisation warrant acute scholarly scrutiny and pedagogical awareness. How does reading change as laptops, tablets, e-readers, and smartphones replace paper and books in classrooms, as well as in leisure reading contexts? And what do educators and practitioners need to know to harness the best of analogue and digital technologies to the benefit of their students?

Whether for researchers or educators, the topic of reading and digitalisation is too complex for simple definitions and operationalisations. Reading research is carried out within a number of different disciplines, applying a vast range of theoretical perspectives and methodological approaches, and the teaching of reading rests upon numerous assumptions based in various—occasionally opposing—models and frameworks of reading. At a general level, this diversity maintains an ongoing schism in reading research, wherein (neuro)cognitive

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and sociocultural perspectives remain ignorant to one another (Mangen & van der Weel, 2016). Rather than arguing for the superiority of one approach, the objective of this chapter is to present a different understanding of reading—one that acknowledges that reading is both a neurocognitive process and a historically contingent sociocultural and deeply personal phenomenon. We will, in what follows, make the case that reading can be fruitfully understood from the perspective of 4E and distributed cognition (Cowley, 2011; Järvilehto et al., 2011; Kravchenko, 2007, 2011).

A 4E and distributed cognition perspective embeds cognitive tasks in environments of interactions. In reading, this translates into questions of the cognitive role and function of technologies and substrates in reading different types of texts for various purposes. Reading is always intimately connected with, and shaped by, the technologies we use when we read, and the increasing use of digital technologies reveals how there is more to reading than what meets the eye. Navigating in and between texts is different with a screen than with a print book, and the substrate of paper affords note-taking and highlighting differently than a digital device. Irrespective of how it is defined, reading is fundamentally an embodied and multisensory process (Hillesund et al., 2022; McLaughlin, 2016). Importantly, the embodied and multisensory aspects of reading apply equally to the 5-year-old learning to connect the sounds of letters and words to the symbols on the page, to the student reading scientific articles on their laptop, and to the commuter reading a paperback novel on the train. As such, a 4E and distributed cognition approach invites a conceptualisation of reading, which has the potential to establish a multidisciplinary field of reading research.

In this chapter, we discuss some ways in which reading is currently changing due to increasing digitalisation. Applying insights from 4E cognition, we discuss how reading is an embodied, multisensory, material engagement with a text. Like all personal experiential processes, reading draws on the past, present, and future. As such, reading entails traces of multiple time scales that play a role for cognitive and affective-embodied aspects. In what follows, we suggest ways in which insights from 4E and distributed cognition (cf. Hutchins, 1995) may help shed light on these fascinating yet largely uncharted territories of reading.

Reading as multisensory engagement with material substrates

Reading is fundamentally multisensory, entailing embodied engagement with a text displayed on a material substrate such as a screen display or a paper page (Hillesund et al., 2022; Mangen & van der Weel, 2016). Reading is thus best described as multimodal material interaction. It involves audio-visual and tactile, haptic, and even olfactory (i.e., smell) perception. A printed text affords a tactile sensory-motor interaction and allows the making of material traces—e.g., "dog-earing" and scribbling in margins. Digital texts afford a different kind of mediated material interaction—e.g., swift and efficient look-up of

words through dedicated search functions. The length of a printed text is reflected materially in the thickness, heft, and weight of the book so that readers always both feel and see their progress and location. On a digital device, such information is supplied (audio)visually, and experiments have shown that these "material anchors" of paper may support cognitive aspects of perhaps especially long-form reading (Mangen et al., 2019; Schilhab et al., 2018).

The notion of perceptual texture and the associated role of sensory-motor processes in reading is closely aligned with ecological psychology and with Gibson's (1977, 1979) concept of *affordances*. What we attend to in perception, according to Gibson, are the affordances of things and objects—the opportunities for action that objects, tools, and things provide. Applied to reading, the substrate of paper (e.g., in books) and the substrate of screens (e.g., in tablets, laptops, and smartphones) differ with respect to interaction dynamics.

There is texture and physicality in reading, but existing reading research paradigms lack appropriate theoretical and methodological approaches to address these key dimensions. For a long time, reading has been understood and studied largely as a visual, disembodied process of abstract information extraction. On the one hand, research in psychology and neuroscience has developed massive amounts of knowledge about what goes on in the brain during reading. On the other hand, literacy research has focused on contextual dimensions of reading, defining it as a situated practice of linguistic and/or semiotic meaning-making shaped by, i.e., sociocultural aspects and commonly employing an ethnographic or semiotic lens. Largely missing are perspectives taking into consideration the role of the perceptual texture of the substrate and how the embodied-affective processes and the reader's sensory-motor engagement with the device and substrate play a role during reading. The next section engages specifically with this challenge.

4E and distributed cognition, and the multiscalarity of reading

Grasping the complexity of reading requires theoretical and methodological tools which allow systematic investigation into the roles of affect, emotions, and embodiment for the reading experience. Emerging insights from 4E and distributed cognition are ideally suited for this task.

4E cognition treats reading as an active, bodily engagement with reading material (Cowley, 2011; Kravchenko, 2011; Trasmundi & Cowley, 2021; Trasmundi et al., 2021). Specifically, the 4 Es—that cognition is *embodied*, *enacted*, *embedded*, and *extended*—share the view that cognition is a process beyond the brain. That reading is *embodied* entails a focus on interaction—for instance, the very act of holding a book, scrolling on a screen, positioning the body, or controlling the gaze. The bodily engagement with the reading material impacts both reading process and outcome. Reading is *enacted* as it draws on habits, norms, and experience, and this is not just a mental memory but a bodily knowledge that shapes emotions, motivations, etc. Reading is *embedded*

in a particular situation, meaning that it is organised in accordance with a broader context, including the purpose, task, and other situational aspects that impact how reading is managed. Finally, reading is *extended* cognition because it emerges from how the reader uses the materiality of the reading situation to make sense—for example, by relying on pencils, rulers, or Post-its to scaffold understanding as part of reading. Rather than deciphering fixed meanings from the text, the reader anticipates what might come next by drawing on affective-embodied experiences and by adjusting to socio-material constraints, whether these relate to the text, the medium, the physical surroundings, or the situated expectations.

In the late 1980s, Hutchins coined the term "*distributed cognition*", and he articulated its main principles in his seminal book *Cognition in the Wild* (1995). The framework underlying distributed cognition is a contemporary product of intense developments in cognitive science from the 1960s onwards. Crucially, cognition is defined as distributed in and amongst people and material artefacts, and over time (Hollan et al., 2000; Trasmundi, 2016, 2020). In reading, the distributed perspective pivots on the ways in which reading involves a web of interrelated processes and mechanisms beyond situated time and space. These mechanisms thus relate to different temporal scales (see Figure 5.1): At one end of the temporal continuum are the processes unfolding in micro scales such as genetic (i.e., pertaining to

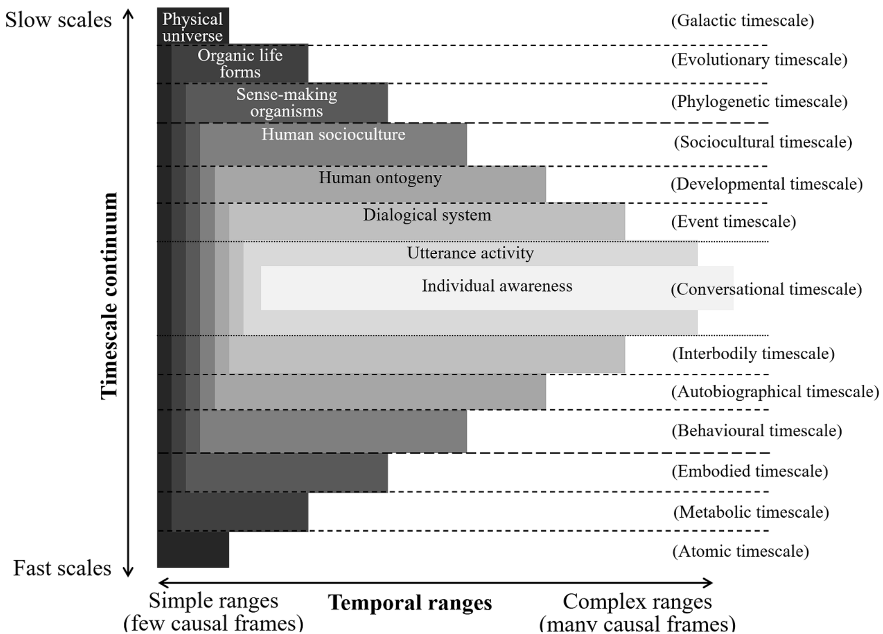

Figure 5.1 Temporal layers in reading. (from Steffensen & Pedersen, 2014, p. 93; see also Loaiza et al., 2020, for an elaborated version of this model).

brain architecture), physical (e.g., the sensory-motor contingencies of reading substrates), and embodied-affective mechanisms. At the other end of the continuum, socially, culturally, and historically contingent mechanisms (e.g., conventions and norms) work according to considerably longer time scales.

Applied to reading, a combined 4E and distributed cognition approach allows us to study cognitive processes as a temporally extended and whole-bodied material engagement. The way reading tends to engage multiple timescales also connects to how it is enabled by knowledge beyond that of linguistic meaning. Even recent neuroscientific studies support this idea and demonstrate how readers' brains operate in different ways during reading. For instance, studies show how different brain areas that process narrative structure, tone, prior knowledge, and emotion are activated with great variability among subjects and readings (Hruby & Goswami, 2011). However, neuroscience struggles to explain *why* different people read differently. Applying a distributed and embodied perspective can add to our understanding in this respect because it focuses not only on the reading brain and its mechanisms but on a reader and their whole-bodied engagement. A recent study of students in teacher education (Trasmundi et al., 2022) explored how personality traits manifest during reading. Correlating personality tests, interviews, and video observations of students' preparatory readings revealed how readers' lived experiences/personalities matter for the reader's choice and organisation of reading location (such as placing things, bringing coffee, food, or light conditions), as well as for reading style (engagement with the text, including note-taking and affective and embodied engagement). A distributed perspective on reading thus allows exploration in relation to timescales beyond the here and now.

Touch and texture in reading

Increasing digitisation warrants attention to the ways in which the different textures of substrates play a role in reading. Reading text on the substrate of paper engages the hands and fingers in more distinct and retrievable ways than reading on a screen. Paper provides the reader with material anchors that facilitate spatial orientation and temporal assessment of the text, whereas a digital screen display does not provide such fixed anchors (Schilhab et al., 2018). Displayed on a screen, the text is an intangible appearance that lacks phenomenological depth and a physical address—it is not "there" in the same way as a text on paper (or other similar substrates). A digital text thrives on malleability, flexibility, and adaptability: it can be adjusted and personalised in ways that a paper text cannot. The lack of depth, fixity, and permanence also apply to seemingly stable textual appearances on screens (e.g., PDF texts read on a smartphone or a short story read on an e-reader), where there is no scrolling but where pages are turned in ways that may *visually* resemble a book (e.g., tapping on screen "lifts" the page).

Studies with younger students show that the materiality of paper and books is important and that an appreciation of touch in reading is not simply a nostalgic longing among older readers who grew up without screens. A survey study with students in grades 6–12 (Mangen & Baron, in press) showed that, when asked what they liked most about reading in print, more than 20% reported the physicality: that they liked the tactile quality of paper, the process of touching and turning pages. Moreover, studies show that students, whether in schools or at universities, continue to prefer print reading over screen reading, especially for longer texts and for the types of reading that require sustained focus and cognitive effort (Mizrachi et al., 2018). Such findings should not be surprising, given that the sense of touch is vital for most tasks we carry out. More than any other sense modality, touch gives us the distinct feeling that objects in our lifeworld are really "out there": "Without vision or hearing, one would inhabit a very different experiential world," writes Ratcliffe (2013, p. 132), "whereas one would not have a world at all without touch". The role of touch in many cognitive and emotional processes—for instance, in reading—has yet to be adequately acknowledged in research, and it needs to be empirically assessed, especially if we are interested in reading motivation, experience, and affection beyond mere functional outcomes such as memory or comprehension. By implication, it is important for teachers to acknowledge that print and physical books have an important role in the classroom alongside digital technologies, especially for the reading of longer and more complex texts. Printed texts also afford note-taking and highlighting differently than digital texts (Baron, 2021; Mangen & Baron, in press).

When reading on paper, the entire text is perceptually present as a coherent material object. The weight and size prompt a perception of a wholeness even when reading a specific text sequence. All pages of the text are materially present and retrievable by specific haptic input (e.g., browsing, using the fingers to locate different text segments, keeping one finger in one location as a bookmark). Our page-by-page progress through the text is kinesthetically, tactilely, and visually contingent. The temporal dimension of reading relates to a spatial dimension too. The page-turning contributes to the understanding of structure and progress. Being halfway through a book is not only relevant in terms of anticipating how much reading lies ahead of you—it also provides the reader with chronological knowledge of how far in an argument or narrative one is (Mangen & Kuiken, 2014; Mangen et al., 2019). In contrast with all of this, when reading on a screen, we may *see* (e.g., using page numbers), but we cannot *sense* our progress through the text. The sensory-motor contingencies of paper inform about the length and volume by concurrent tactile, haptic, and kinesthetic information; when reading on a screen, such feedback is rendered visually.

Recent empirical studies show that the differences in sensory-motor contingencies and substrate texture are important aspects of the reading experience and understanding. An ethnographic study on "embodied reading" (see Jensen, 2022) investigated how students in teacher education programmes

manipulated reading by exploiting their bodies' interactions with the environment. For instance, data shows how readers manipulate the distance of the hand-eye-text relation, how they point in the texts, read out loud, underline, speed up and slow down reading processes, etc. What remains uncertain is how the different contingencies—or coordination dynamics—relate to the different media (e.g., screen and paper) when other aspects of the reading situation change (e.g., genre, purpose, culture, and skill).

In both digital and analogue reading, there are functional manipulations of the material—for instance, page-turning. However, there seems to be less fiddling and less ability to constrain visual attention through digital devices. Also, text proximity seems to be more flexible with analogue reading materials, such as zooming in or out at specific points of the text; this is hypothesised to be crucial for maintaining attention. Systematic empirical studies are needed to shed light on what, when, and how often these manipulations occur and with what purpose. What is beyond doubt is that the hands are crucial reading aids, and their function seems to span functional-aesthetic experiences (e.g., Mangen, 2008, 2016; Trasmundi, 2024).

Conclusion and educational implications

The role of social normativity in guiding action and attention in material engagement is rarely acknowledged, whether in research on reading or in pedagogical practice. The ongoing digitalisation of educational contexts and resources raises important questions regarding the impact of *materiality* for reading, as well as for learning overall. An increasing awareness of the role of embodiment and materiality in reading entails that teachers pay adequate attention to how various types of texts, and various purposes of reading, are better served by reading on paper, in books, rather than on screens. Reading longer texts—for example, textbook chapters, monographs, and novels—is where students overwhelmingly prefer to read in print (Baron, 2021; Hargreaves et al., 2022). Digitalisation is part of any learning setting where technologies (e.g., pen, keyboard, print books, screens) are used, and the material affordances of these technologies are intrinsically entwined with affective-embodied and cognitive processes as we engage with these technologies towards any learning outcome. Hence, replacing handwriting and print reading with a digital equivalent—e.g., keyboard writing, reading exclusively on tablets—are not neutral choices.

Reading is fuelled by digital technology, and because reading is grounded in habitual material engagement processes, the material engagement with texts changes patterns of reading behaviour. Supplementing existing paradigms with a view of reading as embodied and distributed allows a more systematic study of such patterns of engagement, and knowledge derived from such research will better equip teachers and students alike to deal with the range of different reading material they encounter. Preparing coming generations for an increasingly complex information society requires an improved

understanding of how various technologies and their affordances enable and constrain reading towards different outcomes. In effect, that means providing a rich repertoire of texts and considering medium on the basis of which types of texts are to be read and for what purpose. In addition, it entails taking into account the preferences and expectations of students themselves rather than assuming that they prefer to read on screens. Finally, if teachers are trained to detect the particular impact that various reading media have when they are embedded in a particular reading situation, they can make informed decisions about which reading medium to choose and direct their attention to relevant challenges during students' readings as they emerge.

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6 Embodied learning with and through different writing methods

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Introduction

Why do people write? In today's world, writing is essential not only to succeed at school and work but also to function as an active member of society. It stems from our need and desire to communicate with others, and we can use writing to express our feelings, reflect on our experiences, and share our thoughts (Graham, 2018; Graham et al., 2020). Moreover, at school, when writing has become automatic after the first years of learning to write, the objective of the writing action changes, and writing is used to support learning (Frangou, 2020; Gillespie Rouse et al., 2017). While writing generally fosters learning and development, creative writing is seen as a process in which the writer can make sense of his/her experiences and emotions, create and build meanings, and gain knowledge, which leads to reflection and thinking about life from new perspectives (Martin et al., 2021). Writing can also be collaborative and, hence, a social activity in which we learn with and from each other, leading to the expansion of our intellectual and creative resources.

Manual writing tools, such as the pen, have been a means of communication and expression for thousands of years. Hailed as the beginning of automation, the typewriter has been a means of producing characters for about 100 years (Frangou, 2020). The use of computers has increased rapidly in recent decades, and most recently, touchscreen tablets and smartphones have challenged the dominance of computers and have rapidly come into use alongside them. The latest generation favours digital tools for reading and writing over traditional pen and paper (Bouriga & Olive, 2021; Mangen, 2018). Accordingly, contemporary society's needs have led to the progressive introduction and application of information and communications technologies (ICTs) in education. In the renewed Finnish National Core Curriculum for Basic Education, which was implemented in 2016 (Opetushallitus, 2014), cursive handwriting instruction was replaced in all subjects by ICT use. According to the curriculum, students must actively practice their skills in both traditional and multimedia learning environments that make extensive use of digital technology.

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In this chapter, we examine the latest research related to writing using different methods for different age groups. We conclude the chapter by reflecting on writing in light of the 4E theoretical framework, comparing the key findings, and offering recommendations on writing instruction as part of literacy learning in order to meet society's future needs.

Connections between writing and writing methods

Writing is the expression of thoughts through visual symbols, which always occurs through some medium. In the field of writing research, Christina Haas (1996) proposed a hypothesis for an inextricable link between writing and writing methods (how writing is executed), whereby each writing tool influences the writing process differently, depending on how it operates. An example is how the process of letter formation differs considerably between handwriting and word-processing programmes. For the former, letters are drawn by hand, one at a time, with attention alternating between the writing medium and the written text until the process becomes automatic (Alonso, 2015). When typing on a computer keyboard, all ten fingers can be used, and as keyboard skills become automatic, attention shifts from the keyboard to the computer screen (Alonso, 2015). The number of fingers used for typing on touchscreen devices varies depending on the size of the screen, but young people commonly use their thumbs when typing on smartphones (Frangou, 2020; Nicolau & Joaquim, 2012).

Writing with any method is a complex cognitive function that combines conceptual, linguistic, and physical processes (Van Wijk, 1999). Content information and the means for expressing any kind of information in words are encoded grammatically into coherent sentences, which are then processed into motor activity to produce text that can be read (Frangou, 2020). As the writing process becomes automatic, the associated cognitive load changes, freeing up resources to allocate to text design, for example (Yeganeh Doost et al., 2017). Different writing methods, as well as control over these methods, can affect the strength of the memory traces of something written. This is due to the sensory and motor experiences of the writing process, which differ depending on the writing method (Frangou, 2020). Both can result in the same text, but it may be remembered differently by the writer.

Previous studies on writing methods and recollection are inconsistent in their results. Studies based on psychological or cognitive neuroscience approaches have noted a memory-enhancing effect of handwriting that does not arise when typing on a keyboard (Mangen et al., 2015). In contrast, some studies using a multidisciplinary approach to education and behavioural science have found that keyboard use makes text easier to recall (Bui et al., 2013). Whatever their conclusion, the studies mainly focused on single letters, words, or short notes; therefore, the generalisability of the findings is questionable, especially in a school context where the intention is to memorise larger

ensembles than individual words, revealing the need for research on authentic learning environments (Frangou, 2020).

Writing as an embodied activity

The embodied theory of learning highlights the intertwined nature of physical activities and cognitive mechanisms, suggesting that the activation of the body and gestures can positively impact learning (Wilson & Golonka, 2013). Writing can be defined as a biophysical, psychomotor, and cognitive process that produces a final text (Van Galen, 1991); therefore, writing can be considered from the perspective of embodied learning. Essential elements of embodied cognition, the 4Es, are involved in learning to write: embodied, enactive, extended, and embedded learning (Lund et al., 2019). Embodied learning refers to learning as a cognitive and bodily process; enactive learning is learning that is both active and interactive; extended learning includes learning with or through a medium, such as technology, a pen, or a laptop; embedded learning occurs within physical and sociocultural learning environments. Recent studies (e.g., Frangou et al., 2018; Mangen et al., 2015) suggest that the memory-enhancing effect of handwriting arises from embodied cognition: handwriting activates sensory-motor processes that promote recall. Meanwhile, certain studies have highlighted that typewriting requires higher information processing and thus greater cognitive effort, negatively impacting short-term memory (Bouriga & Olive, 2021).

Growing research examines the embodied learning experiences of students and the development of embodied learning environments, for instance, when learning languages (Kosmas & Zaphiris, 2020), mathematics (Georgiou & Ioannou, 2021), biology (Chettaoui et al., 2022), and reading and writing (McClelland et al., 2015). These studies apply various technologies to investigate writing as an embodied act. The findings so far indicate that an embodied pedagogy that combines physical activities with cognition has the potential to improve students' attention, self-control, academic achievements, and engagement. The settings of the existing studies varied but noted similar factors contributing to students' learning. These included, for instance, congruence between body movements and the learning content, multimodal interaction, embodied technology features, and a learning approach that favours students' activity and collaboration.

The concept of embodied cognition in learning to write is relatively new, and only a limited number of models within educational research illustrate how the body and cognition relate (e.g., Frangou, 2020). Further studies must be conducted on learning to write, aiming to investigate how writing skills can be enhanced by applying more embodied and body sense-activating features in writing instruction. Given the promising results of existing research on embodied pedagogy, it is worth studying how the embodied approach could be better linked to research on writing and the development of new instructional methods for writing.

Writers of different ages

In this section, we present two studies for deeper discussion on the effects of different writing methods. These two studies investigated the influence of writing methods on the recall of written stories in different age groups. The studies aimed to identify and describe the writing-related factors that affect knowledge retention.

In both studies, participants transcribed three dictated texts, alternating the writing modes for each text. The pairing of texts and writing modes was randomly assigned and differed between participants so that each text was ultimately written an equal number of times in each mode. The texts were logical stories that did not require prior knowledge. In the first study, the participants' short-term recollections were measured after 30 minutes, and in both studies, the participants' long-term recollections were measured after 1 week. Each time, they were asked to freely recount anything they recalled about the stories. Each story had the same number of memorable details that were recorded as the participants mentioned them. A total of 166 children, adolescents, and university students participated in the studies (see Table 6.1).

The first study had university students writing dictated texts with a desktop computer's keyboard, an iPad's touchscreen keyboard, and a pencil. This study's main result was that the method of writing affected recall to a statistically significant degree. The university students recalled their handwritten stories statistically significantly better than the stories they had typed on a computer or iPad touchscreen keyboard, both 30 minutes and 1 week later.

In the second study, the recollections of 16-year-old teens and 10- and 11-year-old children were compared after writing dictated texts with different writing tools (Frangou et al., 2019). Both age groups wrote stories by hand

Table 6.1 Participants, equipment, and data collection methods of the studies.

	Participants	*Equipment*	*Data collection*
Study I Frangou et al. (2018)	*N* = 31 university students (10M, 21F)	Desktop computer and keypad, iPad & pencil	Measurement after 30-minute and 1-week delay
Study II Frangou et al. (2019)	*All together N* = 135		
Pilot study	*N* =29 (ages 10-11); 19 b.2007 (8M, 11F) 10 b.2006 (6M, 4F)	Laptop computer, iPad & pencil	Measurement after 1-week delay
Study 1	*N* = 63 (ages 10-11); 31 b.2007 (14M, 17F) 32 b.2006 (12M, 20F)	Laptop computer, iPad & pencil	Measurement after 1-week delay
Study 2	*N* = 43 (age 16) b.2001 (21M, 22F)	Laptop computer, smartphone & pencil	Measurement after 1-week delay

and on a laptop. The 10- and 11-year-olds also wrote using an iPad tablet, while the 16-year-olds wrote on their own smartphones. Without being directed to do so, the teen subjects used only their thumbs to write on their smartphones. The results showed that the 11- and 16-year-olds' recall was statistically significantly associated with the writing method, with handwritten stories recalled better than those typed on a computer keyboard or a touch-screen keyboard on a tablet or smartphone. Interestingly, the writing methods used by the 10-year-olds seemed to produce no difference in recall.

Based on the conclusions drawn from these two studies (Frangou et al., 2018, 2019), systematic teaching of typing skills and balanced practice of different writing methods were recommended as teaching practices. Furthermore, the author noted that balancing different writing methods and instruction practices at an early stage is essential for enabling children to acquire the best possible skills for diverse learning and communication (Frangou, 2020).

Recent studies largely corroborate the findings and implications of the research by Frangou et al. (2018, 2019). For example, Bouriga and Olive (2021) compared undergraduate students' cognitive efforts while writing by hand and typing. The first experiment revealed a longer reaction time while transferring thoughts to the keyboard, suggesting greater cognitive effort. In subsequent experiments, a short-term memory task was added involving the recall of typed or handwritten words. The handwritten words were recalled better than the typed ones; hence, typing was considered to require more effort. This led to the authors' suggestion that schools should ensure that students learn to type efficiently, as poor typing skills can negatively influence their learning activities.

Lee (2021) compared English-speaking university students' short- and long-term memories after writing Japanese kanji with a pen on paper and with an Apple Pencil on a tablet. The short-term memory test did not reveal a difference, but the long-term test (after 24 hours) showed increased recall of kanji written on paper. The participating students observed that they needed more practice with tablet-based writing to achieve equal results, given that they had a higher level of motor programme automatisation for paper-based writing. Younger children might not have this imbalance, as they have been exposed very early to digital devices.

Kiefer et al. (2015) studied 4- to 6-year-old kindergarteners' letter recognition and naming, as well as their writing performance and word reading after handwriting and typing. Typing was not identified as superior to handwriting in any task; handwriting produced better results for word writing and reading. Mayer et al. (2020), meanwhile, studied 4- to 6-year-old kindergarteners using a pencil, keyboard, and tablet stylus while learning to read and write. The children were assessed before, immediately after, and about a month after the learning activities. The pencil group performed significantly better than the typing group in letter recognition and visuospatial skills. The stylus group performed somewhere in between. At the same time, typing training resulted in significantly better results for word writing and reading than the stylus

group. The pencil group, this time, performed somewhere in between. The results suggest that writing by hand on paper helps improve letter knowledge and visuospatial skills, which corroborates the findings of Kiefer et al. (2015), while a stylus is the least effective instruction method.

In a final study worthy of note, Spilling et al.'s (2022) findings corroborated those of Frangou et al. (2018, 2019) but differed slightly from the findings of Mayer et al. (2020). Norwegian 6-year-old first graders were taught using both pencil and paper and digital tablet keyboards for the first three months of their writing lessons and then assessed. The findings indicated moderate to strong evidence of a lack of difference between methods, and typing and writing in their other lessons were noted to result in similar text quality. It was concluded that writing performance was not connected to method at this age.

Conclusion and implications

Learning is largely understood to occur in the mind, with action and perception as mere influencing factors (Wilson & Golonka, 2013). Embodied cognition theories, however, view cognition as the result of the simulated motoric action of neural circuits that occurs during learning activities when the learner's body interacts with the physical learning environment. Writing is an activity that entails all of the 4E theory's dimensions: first, learning to write or learning through writing is a cognitive and bodily movement entailing a process; second, it is enactive, with sensory-motor and visuospatial features and interactivity linking embodiment and cognition; third, it is extended as it always needs a medium; lastly, it is embedded, as it occurs in the physical environment and the sociocultural environment of each individual, which influences the writing moment. Writing is achieved through movements controlled by a writer using a particular medium. How such movements influence learning, recalling, and understanding must be investigated so that instructional methods can be improved to achieve the best possible learning results.

Based on the research findings, we recommend that to support writing instruction, teachers should, from early on, balance their teaching of handwriting and typing. To optimally prepare learners for tomorrow's society, it is important to maximise the potential of the various technologies for writing and to teach the use of a variety of keyboards, such as those of desktop and laptop computers and the virtual keyboards of smartphones and tablet computers. Within the 4E theoretical framework, the use of multiple mediums extends the embodied learning experience. This strengthens the different stimulative embodied cognitive processes that learners must adopt to effectively use different writing methods. At the same time, it is equally important to continue teaching pupils and students to write by hand so they can develop various motoric and visuospatial skills, establish sensory-motor representations, and succeed in their literacy learning. To enhance the embodied experience of writing, we recommend the integration of interactivity into writing exercises in order to make embodied learning enactive. Here are some

practical examples of how to promote interaction and foster cognitive socialisation in writing instruction:

- Offer a group assignment in which each person starts a story, another continues, and another finishes it. Then, the stories can be shared.
- Offer pair assignments in which each pair decides on ten words (adjectives, animals, etc.) that need to be in the story.
- Offer a pair or small group a topic that they first need to familiarise themselves with and then make a mind map and collaboratively write about it, possibly even visualising it through drawings.

Furthermore, changing the writing environment and embedding different physical and sociocultural elements in it will not only connect the embodied learning moment in the context but also inspire and motivate the learning writer. Here are some practical examples for creating and providing an embodied writing environment:

- Start with a moment of calming and relaxing silence, eyes closed, to activate the senses.
- Make use of all senses.
    - Aural environments can be created with different kinds of music, nature sounds, busy street sounds, factory sounds, and so on.
    - The visual experience of nature, animals, and art can inspire the writing process. Also, giving the learners a picture (even drawings) of a place with many features, such as a busy street with cars and people, can help the writers' imaginations. Learners can even swap pictures and, after writing, share their own story of the picture and listen to the other learners' imaginative stories.
    - Smelling perfumes, spices, flowers, and so on.
    - Tasting fruits and vegetables, and, if possible, baking something (and then tasting) together.
    - Touching different textures, such as vegetables, leaves, stones, and so on.
- Visit a museum, art gallery, park, supermarket, forest, farm, police car, ambulance, fire engine, garden, market place and so on, where the learners can observe their surroundings with all their senses and then write about their thoughts and experiences.
- Use ready-made book templates with pictures that guide the story.

Many of these practical examples can be modified to fit the needs of diverse pupils, students, and contexts. Learners must be supported early to develop typing skills so that they can play an active role in our digital world, from their studies to their later working lives, as well as in their free time from childhood through adulthood. Contemporary society needs members who can produce, acquire, and evaluate information in any shape or form. Much remains to be

done to provide teachers with the necessary support and resources to teach today's pupils and students different writing methods so that they develop balanced skills.

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7 Long-form silent reading in the contemporary classroom

Kristiane Hauer

Introduction

This chapter explores how an embodied approach to silent reading activities in school creates a more qualified understanding of the challenges that arise in the reading situation during long-form silent reading. This examination is based on qualitative analyses of empirical data from two different studies. The practice-oriented purpose behind this analysis is to clarify how an embodied perspective can support teachers' framing of silent reading activities in a more productive way.

The examination focuses on fiction reading for two key reasons. Firstly, fiction is the most common genre read during long-form silent reading in school. Secondly, the reader must be able to perform deep reading to be absorbed into the fictional world, which is necessary to have a meaningful reading experience (Hauer, 2020). Achieving deep reading competence is thus crucial for reading pleasure and future reading motivation (Guthrie & Wigfield, 2000).

Contemporary pedagogical practices encourage a communicative and interactive approach (Bellanca & Brandt, 2010). This approach influences both the character of the learning activities and the organisation of the physical environment in the class. For instance, learning activities are initiated as collaborative exercises: Pupils are seated at group tables, instructed to move around, or encouraged to leave the classroom and work in open group areas (Hauer, 2020). However, silent, sedentary, and non-communicative activities are also a part of the curriculum. The individual practice of silent reading in class is one such activity, and pupils need suitable conditions to engage optimally in this activity as well.

Individual silent reading requires that the reader establishes and maintains a focused and attentive attitude when at the same time, their embodiments are controlled (McLaughlin, 2015; Wolf, 2016). Thus, silent reading is an activity that McLaughlin (2015) describes as highly "disciplined".

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This bodily mastering of the reading practice is especially significant during concentrated long-form reading, also called "deep reading" (Wolf, 2016; Wolf & Barzillai, 2009). Pupils are expected to perform deep reading in educational settings, though research indicates that this kind of reading has become increasingly challenging for contemporary (young as well as adult) readers due to changes in reading habits and reading attention (Hauer, 2020; Wolf, 2016; Wolf & Barzillai, 2009).

Within the last couple of decades, there has been a growing focus on the body's importance in reading, but the research is scarce when it comes to empirical studies of embodied reading in a school context (Mangen & van der Weel, 2016; Trasmundi et al., 2021). Mostly, the bodily perspective has been related to early literacy practices—i.e., reading aloud or beginner reading activities (Heath, 1982; Trasmundi & Cowley, 2020). When it comes to skilled readers who practise individual, silent, long-form reading, research has focused less on embodied reading processes and more on cognitive outcomes (Cain et al., 2015; Wolf, 2016). There is thus a gap between actual empirical studies of these reading processes and the theory of embodied cognition.

Theoretical background

That reading is an embodied and embedded activity is claimed both in phenomenology (Bachelard, 1958/1994) sociology (McLaughlin, 2015) and in embodied cognition-inspired theories of reading (Kuzmičová, 2016; Trasmundi et al., 2021).

However, the reading body often tends to be empirically overlooked—especially in cases of skilled silent reading—because it is considered a sedentary, immobile, mental, and passive activity. This is also the case in an educational context, which primarily focuses on reading as a cognitive activity related to, e.g., decoding, speed, and text comprehension (Cain et al., 2015). Nevertheless, the embodied perspective highlights that reading is something we perform with our bodies, too, and that body and cognition must be considered inseparable. This embodied approach is also crucial in an educational context (Hillesund et al., 2022).

Deep reading, in particular, requires readers to be able to focus on the text for a longer continuous period. They need to be able to maintain and move their gaze appropriately and not have their attention disturbed by external distractions, such as noises and movements. The materiality of the reading medium—such as screen or paper—has an influence too (Mangen & van der Weel, 2016).

The bodily aspect of reading is also related to the affective and emotional dimension, which is significantly observable during fiction reading. When readers are caught up or moved while reading, both emotions and physical sensations arise in them. For example, the reader can cry or spontaneously burst out laughing when reading (Littau, 2006).

Research shows that we often prefer to read in places that are withdrawn, private, and quiet (Bachelard, 1958/1994; McLaughlin, 2015). A reason for

this may be that we need a safe space to allow ourselves to be transported into the text. For instance, McLaughlin (2015) highlights the bed as a favourite place to read.

In his 1958 book *La Poétique de L'espace* [*The Poetics of Space*], philosopher Gaston Bachelard examines, through readings of literary texts, the character and significance of intimate places and what they mean for us as human beings. Intimate places are where we can withdraw and indulge ourselves in dreams—and in reading. Bachelard emphasises the home generally as an intimate place, and more specifically, beds, nests, wardrobes, and corners. He points out that the corner contains both an openness and a closedness, creating the possibility for withdrawal and for an existential and imaginative openness to the universe.

Anežka Kuzmičová (2016) has also discussed the significance of reading places within an embodied cognition perspective. She argues for a close connection between our reading experience and the specific setting in which we read, claiming that the reading environment affects the reader's attention and experience. The other way around, the reading experience can also influence the reading setting. For example, an anonymous hotel room can become cosy if we read one of our favourite novels during the stay.

Long-form fiction reading in spare time is often practised alone. However, historically, individual reading was typically practised together—e.g., in monasteries and university libraries—before it became a predominantly private domestic activity (Littau, 2006). And an empirical study of current silent reading practice among students in social settings shows that reading in company can have a positive effect on reading concentration (Kuzmičová et al., 2018). It can be more motivating to read together with others because you are part of a social practice that helps to build and consolidate your identity as a reader (and student). Besides, some people feel less alone, and for that reason more safe, than if they read alone at home.

The relation between the body and environment in reading is not only connected to the here and now but also involves the ecology of the reader-text relation—that is, how the reader's lived experience and life circumstances affect their reading situation. Such ecological perspectives have emerged in literary reception theory (Rosenblatt, 1978/1994), in reading sociology (Heath, 1982), as well as in recent reading research within an embodied cognition perspective (Trasmundi & Cowley, 2020). Thus, 4E cognition and a distributed cognition perspective allow for silent reading to be considered as shaped by social, homogeneous dynamics and by individual life experiences that impact the reader's embodiment, cognition, interaction (with readers, non-readers, and reading tools), memory, imagination, etc. (Trasmundi et al., 2021).

Empirical studies

Against this theoretical background, the chapter's empirical study takes an embodied perspective on individual reading of longer fiction texts in the classroom. The data presented derives from two qualitative studies. First, an

ethnographic study that investigates how individual long-form reading in and outside of school challenges pupils' ability to deep read. Data consists of interviews, classroom observations, pupil evaluations, questionnaires, and reading assessments from three grade 8 classes (70 pupils; ages 14–15) at the same school in Denmark and was collected in 2017 (see Hauer, 2020, for an elaborate description of the study).

The second study is a pilot study of the effect of introducing a "reading for pleasure" programme in upper secondary school. This study includes observations and informal discussions with pupils, teachers, and directors from three high schools in Denmark, as well as pupils' responses on questionnaires distributed by the schools. Data was collected from 2017 to 2021 (Hauer, 2021).

The combination of observations of the readers' embodiment and embeddedness in the reading situation and the verbal expressions from the pupils (in interviews and questionnaires) about their reading experience makes it methodologically possible in both studies to adopt a 4E perspective.

In the first study, the pupils are pseudonymised; in the second study, they are anonymous. Except in the case of the first example, the pupils chose the reading material themselves. They all read in print, and consequently, the question about print versus screen reading will not be discussed in this chapter.

As the different studies use different designs, direct comparisons are not possible. However, each study contributes in a different way to how an embodied approach can qualify long-form silent reading in school.

Reading environment matters

During the first study, the grade 8 pupils are obliged to sit in the class and silently read a novel selected by the teacher. These reading sessions illustrate how the environmental conditions impact their reading. The three classes are referred to as class X, Y, and Z.

Class X occupies a spacious room with large windows at the end of a hallway, with plenty of space for the pupils' tables. The teacher frames the silent reading clearly as a learning activity. She kindly calms the pupils down if they become restless, and she indicates exactly how long the activity should continue. The door to the hallway remains closed, except when the teacher opens it to ask the pupils outside to be quiet. Otherwise, she walks around quietly and arranges the room, waters the flowers, etc., as the pupils read.

Both classes Y and Z have smaller and darker classrooms. The pupils' tables take up almost all the space in the room, it is difficult to move around, and the air is often stuffy. The door is occasionally open, and in class Y, pupils are welcome to go outside and read in the hallway at group tables.

A beanbag chair is placed in one of the corners of class Y. It is popular to sit in this chair, and it is often occupied by a specific pupil with high academic and social status. She picks some friends to sit next to her in the corner.

In class Z, there is a particularly high degree of bodily restlessness among the pupils. There is never more than five minutes during the observation without noise. Pupils in this class are allowed to listen to music on headphones while reading, and some choose to do so. One of the pupils tries to sit under his table to read. Another pupil, who has great difficulty concentrating on reading, intentionally disturbs others by making his chair creak. It is unclear for how long the pupils need to read, and they can choose to do other—group-based and communication-based—activities instead.

Afterwards during interviews, pupils in classes Y and Z express frustration over the reading situation that made it impossible for them to deep read.

The pupil Marie says,

– I just can't concentrate on reading at all, even though I really want to. I read only 18 pages today. (Z)

When the pupils later are asked to reflect on "good reading places at school", both inside and outside the class, the pupil Kristoffer exclaims,

– School is probably the worst place to read. (Y)

Otherwise, pupils from the Y and Z classes, who like to read in their spare time, report that they often read in bed or in an especially furnished reading nook that makes it possible to become absorbed in the book. Johannes says,

– I read upstairs in my room. I […] have such a cosy nook I can sit in […] so I can just sit and shut everything out. (Y)

The different environmental conditions for reading in different classes at the same school affect not just the pupils' concentration and ability to deep read, but also their reading experience and the degree of imagination and absorption. The well-defined calm and safe environment that the teacher creates in class X gives pupils the opportunity to perform silent reading together in a productive way. However, the pupils in the other two classes struggle to establish an appropriate calm, comfortable, and focused reading situation that affords deep reading. This struggle is expressed in the pupils' bodily reactions.

Those who want to read seek to establish intimate and withdrawn reading places by searching towards the beanbag chair in the corner or down under the table, or they shield themselves with headphones or hoodies that function as kind of "transportable corners" when no real corners are available. However, some pupils who seem particularly challenged by the activity act out their frustration by obstructing the deep reading practice—for example, through noisy behaviour. These pupils are unable to establish a productive reading environment on their own and need guidance through a clearer and more body-oriented framework.

Undisturbed reading highlights embodiment

Later in the same study, a semi-experimental set-up is initiated. Now, the grade 8 pupils have to read a self-chosen print book, a novel, for 30 minutes while they wear earplugs (instead of headphones with music). While reading, their computers and cell phones are turned off, which means they read totally offline. In this study, all pupils read in class, on their seats, with the door closed for a clearly defined time span and in almost total silence due to the earplugs.

Pupils across all three classes report afterwards that they felt more concentrated and absorbed in the reading than usual. They could better remember what they have read and they had richer mental imagery, indicating a greater degree of deep reading under these specific conditions (Hauer, 2020).

The pupil Josefine explains,

– I think it was like that I could remember more easily, and it was a lot more like that—it all just suddenly became completely quiet [...] and you were not disturbed by anything, so you were just like "inside" the book. (Y)

But many of the pupils also reported becoming exhausted during the reading and noticing their bodies' sensory interaction with the surroundings:

David elaborates,

– I was very focused to begin with, but then I got tired for some reason and then it was like I was starting to notice how uncomfortable the chair was. (Y)

Some of the pupils found it distressing to read with earplugs because they could hear their own body, their breathing, and heartbeat. Thea explains,

– You can hear yourself—how you breathe and the heartbeat. For me, it's like my body is a box I listen into. (Z)

The silence and sonic withdrawal from classmates (and electronic devices) were challenging for many of the pupils. It was beneficial for a focused and absorbed reading experience, but at the same time, it was uncomfortable for the pupils to sense their own bodies. In an embodied and ecological perspective, however, continued practice of the activity would make the pupils more familiar with these sensations and thereby reduce their discomfort.

The experiment confirms that more focus on embodiment and embeddedness can help inform pedagogical reading designs, especially when it comes to deep reading of fiction. This finding leads us to the last example, where an embodied approach is shown more explicitly.

Embodied grounding during silent reading fosters motivation and deep learning

In recent years, numerous Danish high schools have launched a sustained silent reading initiative often called "reading for pleasure" (*lystlæsning*) (Hauer, 2021). The purpose is not only to strengthen the pupils' reading competences and joy of reading but, more broadly, help them to develop and thrive.

At one of the high schools (Tårnby Gymnasium), the reading for pleasure activity is always kicked off by the principal, who uses the loudspeaker system to announce when it is time to practise silent reading together. Another school (Ørestad Gymnasium) has an experimental interior design with a large open space containing several floors, where the majority of the school's pupils literally sit and read together. This points beyond the class to a larger community, where pupils simultaneously and in company can train an individual learning activity. At other schools, pupils are allowed to sit as they please in class—for example, on the floor or with their legs up. Hence, they are allowed to establish a "safe space" or a "reading corner" which affords the best conditions for deep reading.

Questionnaire surveys collected at the high schools generally show great support for these initiatives among the pupils (Hauer, 2021). Four pupils from the Falkonergårdens Gymnasium explain why they like the initiative:

– It is nice, relaxing and you create a calmness inside yourself, in contrast to the very heavy text you sometimes need to read [for studying]. It gives you a sense that reading is not only boring.
– It calms you down and you can find yourself before the [next] class starts.
– I think it's a good idea and it's helped me read more.
– It has given me inspiration to read in my spare time and I read my homework faster and with greater pleasure.

These comments reveal that silent reading activities based on self-chosen reading material offer the pupils the opportunity to withdraw and calm down. It supplies them with energy to cope with a challenging school day dominated by more extroverted and communicative activities.

This bodily cognitive contemplation offers not only a break but also provides better conditions for focus and concentration. There seems to be a connection between embodied grounding and the possibility of more concentrated and deep learning (Hauer, 2020).

However, the pupils report that the effect is missing if they are embedded in an unpleasant, interruptive environment. Observations also show that it is of great importance whether the teacher participates in—and thus bodily "performs"—the silent reading activity the same way as the pupils.

According to the pupils, the activity strengthens both their reading practice and their motivation to read—even beyond the school setting for some pupils. At the same time, silent reading helps them to read homework texts in a more concentrated way.

It is thus likely that the bodily cognitive habit, which is strongly manifested through sustained silent reading for pleasure, has an impact on other similar silent, individual, and independent activities inside and outside school.

Discussion and implications for education

The empirical studies throw light on very different conditions for the pupils' silent reading activities in school. As the first example shows, a calm, comfortable, and clearly defined reading environment, with a supportive teacher, offers pupils the best possibilities to concentrate and absorb themselves in the text. However, the school does not always provide opportunities for this engagement, which is especially problematic for pupils who are strongly challenged in terms of reading motivation and ability to practise deep reading.

The second example confirms that deep reading does not mean less bodily awareness but seems to create a stronger environmental sensibility and embodied experience. This is also the case in absorbed fiction reading, even though it is an activity often associated with disconnection from the real-world setting.

Both examples reveal that individual silent reading is a cognitive challenge, conditioned by the materiality of the environment as well as social interaction. When some of the more challenged readers react by disturbing other readers, it is particularly problematic because individual reading in company potentially makes the reading experience more comfortable and safe. Silent reading together in the contemporary classroom can—within the right framing—also be productive, which is confirmed by the last example. However, it is worth noting that the pupils here are older and study on a higher academic level compared to the first study.

Both studies show that, at all levels of the school system, when silent reading is practised it is crucial to consider embodiment and embeddedness—including environmental framework, social interaction in the class, the teacher's behaviour, and, ideally, the individual pupil's reader identity and reader history—to create the best conditions for focused deep reading, as well as a pleasant reading experience.

Successful silent reading not only supports general reading skills and strengthens reading pleasure but also makes the reading experience more valuable for the reader. It gives pupils an opportunity, in a communicative and extroverted school life, to withdraw and find a mindful bodily state that can also contribute to well-being and a state of thriving. Besides, the bodily cognitive training of independent silent reading as an individual, cognitively demanding learning activity potentially leads to or improves other individual and independent in-depth learning activities. An embodied perspective on long-form silent reading can, therefore, be transferred to similar learning activities, where pupils must be able to perform—and feel comfortable with—focused and concentrated work on a specific task.

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8 Education in the cognitivist and embodied paradigms

Why won't my students read?

Juan Toro and Sarah Bro Trasmundi

Introduction

While it is a fact that teenagers, in general, read less than before, struggle with long-form reading, and report a decline in the joy of reading (see Baron & Mangen, 2021; OECD, 2019), it is a remaining question what causes this unfortunate development. The answer is most likely that it is not only one thing but rather a mix of different sociocultural and technological conditions. In this chapter, we do not intend to provide an overarching explanation of the causes. Rather, we want to point to one element that we consider relevant across (reading) cultures, which will serve as one tangible starting point (of many) for changing the trajectory: the disembodied assumptions underlying how reading is conceived and taught at schools and universities. These assumptions consolidate in a view of reading as a matter of mentally decoding symbols. A mental view on reading entails a brain-bound teaching strategy which overlooks how the body is involved in sense-making of a text (cf. Trasmundi, Holmstedt, & Nielsen, 2022a; Trasmundi, Mangen, et al., 2021; Trasmundi, Toro & Mangen, 2022b).

While there is a dawning realisation that the body is crucial for meaning-making in reading, this framework is only currently being developed in empirical studies of reading. Further, the reading paradigms continue to disagree about the role, function, and value of the brain, body, and context for reading processes. The disagreement originates in opposing conceptions of the mind. In one view—cognitivism—the mind is treated as a computing, data-crunching machine (see Simon & Newell, 1964). In an alternative view—embodied, extended, enacted, and embedded cognition (4E cognition), which is the central theme of this book—the mind is treated as emerging from the body's adaptive interaction with the environment (see Thompson, 2007). The way we conceive the mind's nature has deep implications for how we understand learning and its related processes, such as memory, perception, and problem-solving. These implications are not just scientific or philosophical; they are primordially practical. Cognitive assumptions of how learning emerges are reproduced across societal domains and are reflected in education policies and practices in classrooms (see Slavin, 2018).[1]

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We continue by presenting two opposed conceptions of the mind—cognitivism and 4E cognition—and relate them to learning. Then, we focus on two central issues in education that play a crucial role in how reading is taught, learned, and assessed: (1) the notion of (reading) *habits* and how they can either foster or inhibit imaginative and critical reading processes, and (2) the notion of *microaggressions* that describe how teachers inadvertently implement a specific model of reading that discourages abnormal or deviant ways of reading according to the learning culture. We conclude by reflecting on how implementing some core assumptions of the cognitivist model of reading impacts the students' experiences negatively, and we offer recommendations to enhance conditions for students to enjoy reading and to engage creatively and critically with the text despite the effort that it demands.

Cognitivism and 4E cognition

The origins of cognitive science date back to the 1950s. Inspired by Alan Turing's development of the Turing machine, the analogy to understand the human mind was the computer. The computer metaphor was simple and convincing: humans manipulate information just like a computer does. Humans receive an input through the senses, generate a representation based on that input, and then act in accordance with that representation (output). Importantly, in this model of the mind, cognitive processes occur within the brain, and the person's body is merely an instrument to obtain inputs and execute outputs. This cognitivist conception of the mind has been highly influential in academia and beyond, permeating educational practices (see Slavin, 2018; Trasmundi & Cowley, 2020). As Jerome Bruner, a central figure in the educational sciences in the 20th century, formulated it, "There is a widespread and not unreasonable belief that we *should* be able to discover something about how to teach human beings more effectively from knowing how to programme computers effectively" (2009, p. 160, emphasis in original).

Up until the 1990s, cognitivism was the dominant model of cognition, and even though many competing theories currently question this model, it continues to be endorsed, at least partially, by many cognitive scientists. For the purpose of this chapter, we focus on two tenets of cognitivism that are still at the basis of many theories about the mind: the role of the body in cognition is secondary (non-constitutive), and the cognitive processes are in principle explainable in terms of brain processes (see Adams & Aizawa, 2010). These are the theses of cognitivism we make reference to when we talk about cognitivism in this text). One of the strongest critiques of cognitivism was developed in the late 1980s and early 1990s: In embodied cognition, the body's relation to its environment plays an active role beyond its instrumental function (see Thompson, 2007).

The general claim that many theories within the embodied cognition paradigm share is that in all cognitive processes, the body, the mind, and the world are co-dependent constituents of meaningful agency. According to embodied

perception theories, an individual does not scan the environment for objects to be represented in the mind, and perception is not neutral. Rather, an agent's perception is already meaningful. Depending on (in our case) a reader's bodily skills, needs, desires, and practical knowledge, they can exploit what the environment offers in various ways (see Gibson, 1979; Merleau-Ponty, 1945/2012). Consider how a book invites multiple uses depending on what you want to achieve: read, decorate, hit an insect, etc. Gibson (1979) called such invitations "affordances". The claim that we perceive the world as opportunities for action has great potential to address topics like creativity. Being creative is heavily dependent on the capability of a person's ability to exploit and discover new ways of engaging with the world, so the landscape of affordances constantly changes and emerges in accordance with the person's engagement (Rietveld & Kiverstein, 2014). This engagement is essentially an embodied skill as the person's action and perception become interdependent: new affordances emerge as a result of the person's interaction with the world. Certainly, this idea has direct implications for how we design learning situations in education, and the crucial question is, "Which affordances for learning do we intend to create for students?"

We subscribe to 4E cognition, which treats reading as a fully bodily phenomenon. Reading emerges as the reader engages in culturally learned ways with the written material. It involves the reader's brain, body, and engagement with the environment. Imagine how the reader engages the whole body when they leaf through pages, read out loud, point in the material, look away from the text, impose rhythmicality through bodily movements, etc., to control sense-making processes in reading.

Embodied learning thus involves interaction with the environment. In school, reading practices often involve interactions with other students and teachers, and also involve a mix of different tools (books, digital devices, pens, rulers, etc.) which afford different bodily actions (vocalising, gesturing, etc.). Yet, reading—in the embodied perspective—emphasises the multimodal aspects of how readers make sense through such interactions. Embodied cognition can shed light on issues that had, until recently, been neglected by cognitivist-inspired approaches, that treat reading as dependent on only mentalistic mechanisms (see Agustini & Francesconi, 2021). Since habits permeate all cognitive processes, including the way we engage with tools and interact with other people, we consider habits to be a central topic to understanding processes of learning involved in reading.

Habits

The embodied approach to cognition conceives habits in organicist terms, inspired by a long tradition initiated with Aristotle and developed in the last century by Merleau-Ponty, Dewey, and Gibson (see Barandiaran & Di Paolo, 2014). For this organicist trend, "habits are also related to a plastic

equilibrium that involves the totality of the organism, including other habits, the body and the habitat they co-determine" (2014, p. 5). Habits are thus not mental but bodily inclinations to do things in specific ways. This inclination develops from a history of engaging with the world which sediments as a form of bodily identity (see Aagaard, 2020; Merleau-Ponty, 1945/2012). Thus, habits constitute the very style of a person's way of being-in-the-world based in experience, including how they relate to other people, attend to what is considered valuable, and ignore what is irrelevant (see Maiese, 2021). The guidance in the formation of habits that prepare students and pupils to engage with the future is, ideally, one of the main goals of education.

Importantly, in the formation of habits, there are genetic, psychological, and sociocultural constraints. In this chapter, we emphasise the power of social constraints that sculpt the reader's engagement within a certain sociocultural practice. While the shaping of habits in the social domain is necessary for performing regular tasks, it also fixates the reader's habits. The stronger the social norms, the stronger the tendency to fix habits. When fixation of habits develops, it reduces the capacity to explore, create, and find alternative affordances in reading. The paradox in current reading practices reveals itself: We want students to follow rules (syntactic, semantic, and analytic rules to manage fluency, precision, and speed), but we also want them to be creative and critical, which requires that they read slowly and stop and reflect. We argue that this balance between fluency/speed and stopping/reflection seems to be downplayed in Western reading practices at best, it is trained as an analytical skill applied after the actual reading, but not *during* reading, which is our point here. Hence our focus is to explore how one kind of reading habit dominates and manifests, and how, eventually, it leads to a decrease in the joy of reading.

Habits in reading

Some of the main habits that university students and school pupils struggle to develop and enact during reading are linear, silent, and still reading. This struggle stems from educational standards that describe the "good reader" as a silent reader, sitting at a table in a correct reading posture, focused on constant and fluent symbolic decoding. This focus entails enacting a continuous reading flow, avoiding breaks from scanning, and using knowledge to deduce or retrieve what is most important in the text. We have observed these habits in a semi-experimental study designed as part of a larger research project aimed at studying how university students read. In the study, students aged between 21 and 30 years old read a short story and an academic article on paper. We present here some of the experiential reports they gave as a way of substantiating our claims.

One of the students in the experiment almost proudly reported he managed to maintain focus throughout the reading:

> I think I was able to stay focused on the narrative and stuff like that, because this time I didn't take any breaks.… My mind didn't wander off to anything else.… I did try to like, make some perspectives to also myself, my own life and stuff like that, but nothing that made me stop reading.

The utterance indicates that students learn that breaks are undesirable interruptions. They are taught that one central feature of skilled reading is that of keeping non-related thoughts at bay. Another participant said that with a short story,

> [Y]ou speed through it a little bit. I mean, to speed through is a bit harsh, but you go through it a lot quicker. You don't need to make breaks.

The habit of controlling attention is coupled with bodily positioning: how to sit, hold the book, maintain gaze on the symbols in the text, etc. When the student is taught to sit still and eventually read silently, the instruction reenacts an ideal of reading as an activity where the body is a disturbance rather than an affordance. Surely, still reading is also a case of embodied reading, but it is a limit case, in which most of the affordances in the environment are being ignored, with concrete effects: It has been widely documented that embodied processes enable and constrain in specific ways memory and comprehension of texts (see Hillesund et al., 2022; Mangen, 2016). As an example, consider how reading out loud a few words in a text helps in making sense of them. One participant in our sub-study elaborates:

> [S]ometimes when I read some of the texts for class, which have some longer and more complicated words, it helps me to say them out loud because otherwise my brain makes like a word mumbo-jumbo—then I have to slowly say it out loud, because otherwise I'll be like "what?"

Reading out loud is often discouraged in the classroom, the student notes, leading her to restrain herself from doing so. She also reports,

> [U]sually I only do that [reading words or sentences out loud] when I'm at home by myself. So, the moment I step outside of my own room, I stop.

Reading out loud and silently are very different embodied processes; however, the cognitivist approach makes no distinction because it prioritises abstract information over concrete form. Further, since the reading research based on the cognitivist paradigm has focused on reading as decoding, self-initiated interruptions (breaks from ocular scanning that are caused by the reader themself and not by, e.g., external disturbances) are deemed outside the task. We argue that an embodied perspective, which includes the context of reading, is better suited to embrace those breaks as affordances for creative and critical reading. See Trasmundi et al., 2024, for an analysis of how expert readers develop embodied strategies according to specific demands of the text and the task at hand.

The importance of self-initiated interruptions, along with other embodied strategies that deviate from the steady flow of reading, is illustrated by one of the participants in our study. She elaborates on her experience of reading a short story:

> At some point I stopped [reading] because I was like, 'well, this could be me!'

We argue that it is in those self-initiated interruptions that the reader establishes important connections between the text, their personal experiences, and imaginary possibilities—connections that are crucial for creative and critical forms of reading.

Microaggressions

Now we turn to the part of our argument that links the educational context with the view which promotes fixed and silent bodily habits of reading elaborated earlier with younger readers' reluctance to engage in reading. We claim that these habits are enforced in students and pupils by educational teaching practices that reflect a specific ideal of reading and learning. By that we mean that teachers (1) tend to teach in accordance with social expectations and mainstream, cognitivist reading models, (2) they use pre-designed tools available for teaching, and (3) they assess reading performance in accordance with policies, curricula, etc., presented to them. Our claim is that teachers—and students—conform to the norms and expectations in this particular education discourse. To enforce those norms and expectations, teachers often resort to microaggressions in the classroom. Specifically, our claim is that microaggressions, in this context, target embodied styles of reading that deviate from the ideal of a silent, mental, fluent reading pattern.

The notion of microaggression refers to subtle, usually automatic, and nonverbal forms of discrimination experienced by minority groups (Pierce et al., 1977). Despite their subtlety and apparent innocuity, Pierce (1970) claims that "[t]he enormity of the complications they cause can be appreciated only when one considers that these subtle blows are delivered incessantly" (p. 265).

There are four elements of microaggressions that make them relevant for our discussion: (1) they are exerted by members of a hierarchically superior group (teachers) to hierarchically inferior persons (students/pupils); (2) they are constant throughout an extended period; (3) teachers do not mean to degrade students even though students do feel misjudged; finally, (4) they highlight that the pupil/student deviates from some norm (cf. McTernan, 2018).

Building on our sub-study and also a previous, large ethnographic study on reading practices (see Trasmundi et al., 2022a; Trasmundi & Toro, 2023), we propose that teachers—mostly inadvertently—apply microaggressions in the classroom to implement a specific model of reading. Since the cognitivist model of reading focuses on mental information processing, those aspects of

reading that deviate from that model are seen as inadequate and dysfunctional "noise". Deviating strategies of reading, like vocalising, moving around, mind wandering, engaging in extended imaginative processes, reading non-linearly, etc., are often perceived by teachers as a lack of concentration, task switching, and generally as behaviours to be corrected since they do not fit into the ideal or the "socially correct way of reading" (see Trasmundi et al., 2024).

Importantly, it is often bodily changes in reading that are seen as most problematic (gazing up, moving, imposing rhythm, etc.) because they are seen as disturbances and non-cognitive in the cognitivist perspective. For that reason, they are most commonly targeted through microaggressions. A microaggression could be a teacher's gesture, such as a raised eyebrow, using index fingers to correct and guide the reader's attention, silencing those who start vocalising, emphasising the importance of speed, flow, and accuracy over other aspects, etc. One challenge enforced by the cognitivist, disembodied view of reading is that the affective-experiential aspect is downplayed, a dimension which, in our data, proves crucial for the reading experience—both in terms of understanding and connecting and engaging with the text more broadly. Motivation indeed determines the experience and the quality of reading. This was a recurring topic raised by participants in our sub-study. One mentioned with

> Obviously motivation also matters. Sometimes I just feel 'I don't want to do this'. And then, obviously it's very hard to concentrate.

And another mentioned,

> I'm a picky reader. When it comes to books, I am. I have to be 100% invested. And if I am 100% invested I am like "Oh, what is the next page?". That's why I just kind of go through it really quickly.

Recommendations for education

These few qualitative excerpts underline the need for alternative ways of understanding reading that overcome the mentalistic limitations of the cognitivist approach. We suggest a model of reading in which open-ended processes of bodily engagement—such as creativity, imagination, and critical thinking—are foregrounded (see Malafouris, 2013; Noë, 2015). First, this embodied alternative is a more true-to-life model of reading which emphasises the multisensory aspects of reading and favours messy reading patterns where breaks are part of the process. Second, the alternative model can potentially revolutionise the educational system as it encourages teaching a broader portfolio of habits. Naturally, this shift of attention would require a corresponding shift in how reading is taught, assessed, and valued. Over time, it will lead to different habits as readers adapt to social rules of engaging the body more intelligently in the reading. We anticipate that those habits are more aligned with a natural, playful form of engagement and that they, in turn, will generate a more joyful experience for the reader.

Surely, enabling conditions for the student to become an engaged and motivated reader depends on many elements, many of which are beyond the control of the educational institution or the teacher. However, a starting point for teachers and policymakers to change the current situation of disenchantment with reading is to become aware of these elements that have remained hidden for so long. Those are (1) that the model of reading currently aligned with teaching in school reflects a conception of the mind that is flawed and problematic if the aim is to educate critical and creative thinkers and make education relevant, joyful, and engaging; (2) that inadvertently, well-meant teachers are enforcing this model in classrooms through microaggressions; and (3) that the model of reading being taught neglects some of the most relevant cognitive processes in reading—namely, those related to the reader's embodied engagement with the text in context.

Conclusions

On a par with the pragmatist philosopher John Dewey, we suggest treating all learning and teaching practices as cases of material engagement, or, with Dewey's terms, "progressive education" (Dewey, 1938). This engagement is especially valuable for memory and experience if the student is free to use creative, imaginative processes as part of interpreting texts.

Malafouris (2013) has developed a theory of material engagement in which he argues for the importance of an object's materiality for cognition. For instance, reading on a screen provides a different material substrate than reading on paper, which in turn impacts how a reader interacts and experiences the engagement (see Mangen & Kuiken, 2014). Further, reading is an exploratory activity grounded in sensorimotor contingencies of material engagement (Malafouris, 2013). In that sense, a 4E cognition framework puts pressure on the received view of reading and opens up creative and participatory forms of material engagement with texts. We argue that this insight will help teachers loosen fixed reading strategies and inspire them to use the analytical tools in accordance with those findings. Hopefully, this change in perspective will make a positive change in students' reading habits.

Note

1 There is a debate about the actual influence of cognitive models in educational practices. Olson (2003) claims that the impact of cognitive theories in educational practices is "modest if not negligible" (p. ix), whereas Bruner (2009) and Slavin (2018) show how cognitivist educational psychology has been an important resource to develop educational practices. We will not address this debate here.

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Part IV

Aesthetic learning

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9 Thinking through hands in education

Camilla Groth and Marte S. Gulliksen

Making sense and knowledge creation

If all cognition is embodied, the need to talk about embodied cognition as something distinct from any other type of cognition is redundant (Gulliksen, 2017, p. 8). In effect, this means that the division between theoretical and practical subjects is also superficial—for example, mathematics, which is traditionally thought of as abstract and immaterial, can be argued to be deeply grounded in kinesthetic and somatic experiences (Abrahamson & Lindgren, 2014, p. 358). In this chapter, we explore the role of the body in sense-making with and through hands and materials. We look especially at examples in arts and crafts and how embodied learning in these subjects may develop skills and knowledge useful in other domains.

Arts and crafts involve aesthetic learning and making that require bodily interactions with materials, in which the learner needs to make use of the whole sensory spectrum. Learning is thus *embodied* and *situated* in that context. It is *extended* through the interaction with tools, materials, and others, and it is *enacted* through the making of artefacts. The word "aesthetics" refers, amongst other things, to a sensation of the senses and sensory experiences in a more general way, not only connected to appreciation of beauty. In aesthetic learning processes, the learner is sensitised into paying closer attention to notions of sensory experiences and subtle changes, making sensory evaluations, such as judging matters of taste, balance, dimension, shade, consistency, or depth. All of these processes require a close, intimate, and reflective relationship between the learner and their environment (Strati, 2007). Our sensory modalities—such as vision, hearing, and touch—constitute the contact point between the learner and their surroundings. The visual sense has traditionally been given preference, and in many ways, we live in an ocular-centric world (Howes, 2014). However, when interacting with materials, other more proximate senses are just as important. For practitioners of arts and crafts, the haptic system is adamantine, as hands are used for most tasks in the studio. There is also evolutionary evidence explaining the role of hands in the development of the brain (Wilson, 1999). Thus, there are good reasons to pay attention to the role of hands and haptic, tactile, and kinaesthetic experiences, especially in education (Søyland, 2021).

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In the field of professional craft, practitioners think, feel, and make judgements; plan; and theorise *in action* and in direct negotiation with the materials (Malafouris & Koukouti, 2022). Arts and crafts education is the subject in which we can bring this aesthetic form of sense-making through material interaction to pupils in schools. The act of making something in a material may be seen as more than just manipulating materials or forming it into a desired shape: It is, in many ways, a conversation or negotiation between the maker and the material environment (see Figure 9.1) (Brink & Reddy, 2019; Malafouris & Koukouti, 2022). By manipulating material, we affect the environment, but we are also affected by the making experience itself (Groth, 2017). In the Nordic countries, the subject of arts and crafts, or rather "sloyd", has an extended pedagogical agenda of cultivating not only practical content knowledge but also appreciation for work morale, quality, accuracy, cleanliness, and neatness, and for the development of independence, self-reliance, and mental stamina (Salomon et al., 1907).

The craft practitioner's process includes taking risks and, therefore, inevitably also failure. Problems related to materials and techniques emerge and need to be worked through and solved. Teachers guiding craft learners are aware of this and can take this into account when designing assignments, helping pupils to "fail early" in order to help scaffold their creative processes and facilitate their problem-solving and generation of new ideas (Sawyer, 2018, p. 158, p. 164). Through such trial and error, craft practitioners become comfortable taking risks when manipulating materials and learn to utilise "safe failing" as a

Figure 9.1 Child learning how to carve fresh wood with a spokeshave. Photograph by Marte S. Gulliksen.

way to move the process forward. This way, the craft practitioner grows their resilience (Huotilainen et al., 2018).

As we process ideas into artefacts, we also make meanings, and through these artefacts, we share and communicate those meanings. In a similar manner, we might think of knowledge as something we create through our interaction with our environment, other people, and other peoples' creations such as drawings, texts, artefacts, performances, songs, plays, or films. In a learning context, artefacts can be seen as epistemic objects that, especially in collaborative learning, carry the process and knowledge created in the group (Knorr-Cetina, 2001). Learning can thus be seen as a process of knowledge *creation* (Paavola & Hakkarainen, 2005) that becomes especially noticeable in materially based subjects such as arts and crafts. The process of handling materials is thus closely linked to handling knowledge: making is thinking through hands (Groth, 2017). In schools, craft practice offers the opportunity to make sense of the world and develop our manual skills, problem-solving abilities, and sense of accomplishment and resilience. Arts and crafts are ideal contexts for concretely "getting in touch" with our environment and the materiality that surrounds us. This makes the subject a premise supplier for other content, such as STEAM and invention pedagogy (Korhonen et al., 2022) and environmental sustainability (Fredriksen & Groth, 2022).

Sense-making and the role of action in cognition

This chapter is called "Thinking through Hands in Education"; however, the concept of sense-making is more precise, and we will use it to explain this notion more closely. The meaning of *sense-making* is connected to utilising our senses in the act of making meaning. Sense-making is a key concept in enactivist philosophy, a branch of embodied cognition theory that emphasises the organism-environment coupling, and in which the body is seen as a vehicle in all learning (Newen et al., 2018; Noë, 2004). Enactivist thinking suggests that a person learns through action and accumulates knowledge through their embodied experiences with their environment (Noë, 2004; Varela et al., 1991). The brain's plasticity enhances its capacity for what it is regularly exposed to; this means that the more experiences we have of a certain action or interaction, the better we are at anticipating and predicting possible outcomes from future similar actions and interactions. For example, material properties may at first be experienced as providing resistance before the novice learns how to predict the material's behaviour and how to overcome difficulties in manipulating them. Hands-on guidance can help in learning the exact amount of pressure and timing of movements (see Figure 9.2).

Craft practice requires activation of the body, from full-body interaction, such as sawing and hammering, to fine motor tasks, such as stitching and drawing. A neuroscientific reason for activating our bodies during learning is the fact that moving our bodies activates our brains (Huotilainen et al., 2018). Making small drawings or being active in other ways—for example, by

Figure 9.2 Child throwing clay for the first time aided by hands-on guidance. Photograph by Camilla Groth.

handling material or knitting while listening to a lecture can yield better learning results than just passively listening (Andrade, 2010; Huotilainen et al., 2018). Touching and forming materials, such as typically happens in craft activities, stimulates certain areas of the brain. Physically manipulating and exploring new materials are crucial for healthy brain development (Kiefer & Trumpp, 2012; Lusebrink, 2004).

Learning through material engagement

The notions of experiential learning and of learning by hands-on doing and reflecting on the experiences were initially developed by Dewey (1938).

Through their concrete and material nature, arts and crafts practices offer ample physical opportunities for familiarising with different material properties. During a process of learning and reflecting in and through action (Schön, 1983) and in the predictions of a material's behaviour, the abilities and limitations of one's own bodily strength and capacity are noticed in a new way (Groth et al., 2013). By experimenting to overcome material resistance, students practise problem-solving and can test creative solutions by applying existing knowledge to new contexts. In the next section, we explain this more specifically through examples from previous research.

Examples from arts and crafts education

We briefly present examples of craft education in, primary school education, and higher education to exemplify embodied learning aspects discussed later.

Example 1

In primary education in Finland, craft teacher education recently included multi-materiality as a strategy, moving away from gendered aspects of material-based craft teacher education in either hard (wood, metal) or soft (textile) materials. The craft subject thus facilitates new materials in technology education, in which one strategy is to engage pupils in STEAM subjects through maker-centred learning.

In this example, a group of primary school pupils aged 10–12 are solving a problem regarding their lamp design project (the original study is described in full in Kangas et al., 2013). The pupils have difficulty imagining the height of the lamp over the table: It should ideally hang in a way that no one can hit their head while still allowing enough light onto the table. They build on each other's ideas, using gestures and drawing for communication, and externalise their ideas in visual representations that help them discuss and reflect on the design task collaboratively. As imagination is no longer enough to solve problems on an idea level, prototypes are built, and the physical constraints are made more concrete. The pupils then solve the problem of the hanging lamp by physically standing up on the table and pointing a telescopic pointer down onto the table, thus using both their own bodies and authentic and situated material scaffolds in their problem-solving task. That they collaborate and work on the task together forces them to externalise their thinking through verbalisation and sketching—thus also making the issues articulated rather than tacit hunches. When sharing the problem space with others, cognition is offloaded into the social space, and the problem can be approached from the multiple perspectives represented by each pupil's experiential knowledge.

Example 2

In this example from higher education in design in Finland, the task was to create an artefact for an exhibition as a result of a conceptual artistic process (this case study is described in full in Groth & Mäkelä, 2016). The students created designs in their minds before starting concrete material testing. In a few of the students' cases, these plans were very realistic, and based on previous encounters with materials, they used their embodied knowledge of materials and their constraints in the formation of the initial mental image of their artefacts. The students then externalised their ideas through visual representations and models, and here the students' abilities to make realistic plans for their designs differed to a large degree.

One student used her previous knowledge of materials and their behaviour when encountering new, unfamiliar materials that—to her—behaved unpredictably. She also made use of external aids in the form of scaffolding structures to facilitate her understanding of the construction she needed to make, transferring her 2D idea into a 3D shape. She said that the task could not have been solved solely by thinking but required the whole body in the learning process. However, some other students were not as experienced in handling materials. One student in particular had difficulty creating any material implementations from his ideas. The plans he created were too complicated to be realised in material; he had to constantly reformulate and rethink his designs, but nothing seemed to work in the physical realm. He reflected on this inability to create functioning designs as a lack of experiential knowledge of material properties.

As the students experienced new materials in their exploration process, the new and unfamiliar material behaviour disrupted their workflows and made them question their skills and their identities as makers. The students' anxieties were soon overcome by resorting to familiar patterns and methods of solving material problems known to them from other, more familiar domains. One student listed his many different past skill-learning experiences and called these his "mental toolbox". While all those skills—such as painting, martial arts, diving, and piano playing—were very bodily skills, he still thought of these as "mental" in the way they are carried with him into new situations and constitute part of who he is as a person.

The usefulness of embodied teaching and learning in other school subjects

The domain of arts and crafts education allows for a safe failing and learning environment for gaining experiential knowledge about material properties and

general physical constraints. The concrete materiality in arts and crafts practice offers opportunities to practise overcoming material resistances and grow confidence, and to train in creative problem-solving and making scaffolds as aids for both cognitive and physical constraints.

Embodied teaching and learning highlight the use of situated, contextual, and real-life problem-solving in which learners work on authentic, project-based, and open-ended learning tasks. Material artefacts such as prototypes carry epistemic processes that are modified and iterated through collaboration with others. Material prototypes scaffold learning and help make concrete the problem-solving process, allowing for metacognitive reflections on the learning. Additionally, artefacts carry meaning in another form than the textual or auditory modalities and also tacit and multimodal aspects of understanding. All these forms of learning extend cognition and the learning activity out into the learning environment and make it visible.

Training the ability to find strategies for scaffolding one's own process is relevant in the arts and crafts but is equally important in—for example—mathematics, science subjects in laboratory settings, and reading and writing. External aids are also used in mathematics and physics, which are generally seen as theoretical subjects. On the contrary, there are many examples of extended cognition in mathematics, such as counting by using fingers or an abacus to offload cognitive tasks into the environment (Abrahamson & Lindgren, 2014, p. 362). The ability to create external aids as a habit and strategy for creative problem-solving and externalising thinking can be trained in arts and crafts—for example, through drawing and model-making.

Studio pedagogy in arts and crafts incorporates most embodied learning strategies naturally (Sawyer, 2018). Apprentice learning involves situated and sustained scaffolding that first follows the student closely with real-time guiding and hands-on showing and telling (Groth et al., 2013). Such methods scaffold learning and offer a distributed sense-making process through cognitive apprenticeship (Collins & Kapur, 2014). As the student gets more familiar with the practice, appropriate "fading" of the support gives the student more responsibility for their learning while still having aid close by. Many of these strategies can be applied in other school subjects.

Recommendations for education

Finally, we encourage teachers to consider how they can encourage learners' embodied learning in the following ways:

Understanding abstract concepts

Embodied sense-making is especially useful in the transition from abstract concepts to lived experience through material mediation in the form of prototypes. It is similarly useful the other way around: from the lived experience to the abstract representation. As this skill is a higher-order cognitive activity

fuelled by material interaction, it is also useful in other contexts. For example, when a student in mathematics constructs a pyramid with a pen on a piece of paper, they need to conceptualise the abstract idea "pyramid" as a prospective 3D form in a virtual space and find ways to represent this on a 2D paper. They can thus draw on previous experiences of a physical 3D pyramid to scaffold their understanding of this abstract form.

External aids

Teachers can consciously support students' use of external aids to negate mental overload. Such techniques also help concretise the topic being learned and provide training to create and test learning aids. Active scaffolding is a sign of constructive and creative approaches to problem-solving and opens learners up to thinking outside the box. Material manipulation in or outside of craft practices also aids abstract thinking, as material experiences can scaffold abstract spatial thinking. For example, if the student thinks of a pyramid and needs to imagine how it would look from the side, this is a mental rotation task that can be facilitated by making a mock-up pyramid in 3D that is rotated physically. Social interaction, collaboration, and sharing tasks with other learners are ways of extending and amplifying thinking within the group.

Trial and error

Teachers can facilitate opportunities for trial and error and emphasise the value of experiential learning through making. Providing such situations, learners could build themselves as knowledge-makers and gain self-esteem and a sense of ability and agency relating to their material environment. By engaging in processes that provide material and mental resistance, teachers would also help students learn endurance and perseverance. Additionally, students may be encouraged to experiment in novel ways and in new areas, building innovative strategies for learning and engaging with problems.

Safe failing

Providing learners with a safe and accepting environment that allows them to practise trial and error is important. Failing in material manipulation tasks is safe: Nothing bad can happen; the process can easily be restored, and the learner can grow even stronger and more skilful through overcoming resistance in the process (Huotilainen et al., 2018). Such skill in how to allow oneself to fail safely to learn quicker can be useful in other contexts as well. Previous experience in safe failing could mediate disappointment when meeting new topics and subjects one may be unsure of mastering. For the teacher, this entails finding strategies that allow for individual adjustments and multiple approaches to scaffold safe failing through supportive guidance.

Endurance and perseverance

Manufacturing something well in a material is time-consuming and offers slow but lasting rewards, as opposed to quick and multiple rewards (such as, for example, in gaming). Thus, material making develops perseverance and self-control as well as the ability to wait for rewards. Striving for quality and doing a good job—for the feeling of personal achievement rather than for external rewards—may also teach a sense of work ethic and purpose in life.

Conclusion

In this chapter, we have discussed the role of the body in sense-making through craft practices while highlighting the hands as a connecting point between the learner and the world. We have discussed craft practices as processes of making knowledge and how overcoming material resistance can help build resilience and self-reliance. Key features of learning through material engagements include the importance of gaining experiential knowledge of materials and their properties, and the benefits of being able to scaffold and concretise learning and self-making. On a societal level, different kinds and qualities of making occur in multiple forms, on many levels, and in different contexts. By transforming matter, we transform ourselves and, by extension, society little by little (Groth et al., 2022). Arts and crafts thus work as a premise supplier for other study subjects in which learners may test and engage with content knowledge in multimodal embodied and reflective ways. The relevance of the arts and crafts subject to other domains of life and study is its role as a facilitator of subject content while providing tools for both embodied learning and reflection—a way to connect oneself with the world.

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10 Why whole-body drawing still matters in our digital age

Lovise Søyland

Introduction

When drawing by hand with charcoal on paper, cognition is situated in the sense that it takes place in a real-world environment and involves senses, perception, and embodied actions in real time. Drawing can be seen as a way of thinking because a person's cognition is deeply entangled with the materiality of the world, and thinking is mediated through material interaction (Noë, 2006). Education, in general, is rapidly experiencing a digitalisation of materiality, and arts and crafts education specifically is undergoing digitalisation of what has previously been materially engaged experiences. Manual drawing is partially replaced with drawing on digital surfaces in educational settings. Digital technologies certainly provide new potentials in drawing, such as working with layers and adding modalities like sound and movement. However, when the materials used in the field are rapidly changing and moving into the immaterial dimension, this also brings challenges related to embodiment. Therefore, I will discuss the role of whole-body drawing and why analogue drawing still matters.

As an educator in arts and crafts, I represent a practice that involves haptic and sensorial experiences through "making activities", teaching both analogue and digital drawing. Materiality and material engagement are the foundations of making activities, such as drawing, and highlight the educational potential of "making for learning". Analogue drawing entails intimate encounters with materials and tools and their experienced affordances (Gibson, 1979), properties, and constraints. It involves an immediate path from the moving body and hand to the mark-making on paper and other surfaces. Central to arts and crafts education is that it offers unique possibilities to establish a dialogue with and connect with the world through bodies and hands (Biesta, 2017, pp. 77–9). Through direct embodied entanglement with materials, we make sense and gain experiential knowledge. Materials challenge us and provide different resistances, opportunities, or affordances as we explore, handle, and interact with them. Such material engagement is also vital in the drawing process. Materiality and materials must be experienced to know how they "flow" (Ingold, 2007, p. 14) and what they can do.

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Embodied cognition theory shares foundations that have also been significant for educational arts and crafts. Especially Merleau-Ponty's (1962/2005) phenomenology of perception and Dewey's (1934/2005) pragmatism are closely related, as both argue for the knowing body. Sense-making is a concept derived from the enactive tradition of embodied cognition (Noë, 2006) and is seen as a bodily phenomenon in which the body is always included. Enactivism takes action and perception as the starting point for cognition (Noë, 2006). This means that thinking is embedded in structures of the material environment, and it is extended (Newen et al., 2018) beyond the body—e.g., through the drawing tool. The enactive approach comprises emotions as much as cognition; emotions are understood to be essential ways of engaging and making sense of the world (Thompson & Stapleton, 2008, p. 26). These theories are essential for developing insight into the drawing process, where material-based aspects require embodied sense-making. The utilisation of embodied cognition theories in educational arts and crafts promotes the understanding of making as a cognitive process and as an internal and external process of transformation—a perspective discussed in learning science (Sawyer, 2014).

It is critical for learners to experience material engagement, tangible reality, and bodily movement in three-dimensional environments in real time. When a person works digitally, the body and the hands are not challenged in the same way as in encounters with materials and, e.g., an outdoor environment (Søyland, 2021). Digital technologies can provide new potentials in drawing, but there is a haptic dissonance within them that is important for teachers to be aware of. In a real-world environment with materials in flow, there is potential for enriching learners' sensorial experiences to a greater extent. Experience becomes poorer when the body does not encounter a varied material surface or environment; this affects both the presence and the experience. A shift from physical, real-world experiences like whole-body drawing to extensive use of digital technologies with monotone surfaces is also a shift in the learners' spatiotemporal relation with materiality. I think we are on the verge of losing something fundamental in the learner's experience if we are not aware of this, and we should ensure that learners gain experience with tangible and exploratory learning activities, such as analogue drawing. It is not my intention to make a "for or against" debate about digital drawing but to discuss why whole-body drawing still matters in education.

Tiril Schrøder is a professor at Oslo National Academy of the Arts. In her chapter "Between the Pen and the Line. Digital Drawing and the Feeling of Alienation and Distance", she highlights that the tactile and haptic encounter with materials and materiality in analogue drawing sharpens the presence of the person drawing (Schrøder, 2022, pp. 78–89). Ingeborg Stana, artist and professor at Oslo Metropolitan University, highlights how traditional drawing tools—e.g., pencil and charcoal—give a deep understanding of the materials, what they can do, and the value of experiencing material affordances (Stana, 2022, p. 2). Within digital drawing, she highlights potentials such as quickly

experimenting with different visual expressions, which are slower processes in analogue drawing (Stana, 2022, p. 3).

The guiding research question in this chapter is, *How does sense-making unfold through whole-body drawing processes in an outdoor environment, and why does analogue drawing still matter in our digital age?* There are many different purposes and ways of working with drawing, like observational drawing and conceptual drawing, but here, I focus on the act of drawing as a form of expression through the whole body. I build on an understanding that drawing with large movements affects the learner's ability to create, unfold, and express themselves.

Implementation of the study

I employ auto-ethnographic research (Chang, 2008) to get close to studying body-based drawing practice and knowing from the inside. I also use video and photo documentation and written observations. The empirical material is based on ten site-specific drawings in the forest outdoors during the winter season. During the drawing process, I let the feel of the place affect me. I drew with charcoal on large paper format (2 × 1.5 m) and utilised an open-ended and explorative process. I examine the direct encounter between my embodied mind, the materials, and the surroundings during the drawing process. I also examine how the change in the winter-covered forest over a period of several weeks affects the drawing process, materials, actions, and expressions. The audio-visual recordings captured time and space contingent activities and in this way enriched my analysis. Through video, I studied my own movements, the sounds that I made, and the sounds of the materials and the environment during the drawing processes. I also reflected upon my written observations and photos. The quality of the expressions in my drawings has also been discussed with experts in contemporary art.

Photos and empirical excerpts of key understanding from the drawing process

I present photos and empirical excerpts from four of my drawing processes (see Figures 10.1–10.4). The excerpts are based on my analysis of the video documentation and written observations of my processes. All photographs are taken by myself.

Embodied Drawing #1. The direct expression. Minus 14 degrees. Because of the cold, there is no room to hesitate, direct bodily movements, and expression, breaking out of the notion of drawing by drawing in the wood, an interruption of the traditional way of approaching drawing, new impulses from the materials and the surroundings. A new and different expression arises.

Embodied Drawing #2. High tempo, deeply engaging, and dynamic expression. Minus 7 degrees. Cold and windless. I work in large, slow, rhythmic movements, and I draw with quick, sharp, rhythmic lines at a high pace. I experience a tremendous drive and need to continue and feel how my body is working. I move in rhythm with and feel close to nature and the materials.

Figure 10.1 Embodied Drawing #1. The direct expression.

Figure 10.2 Embodied Drawing #2. High tempo, deeply engaging, and dynamic expression.

Figure 10.3 Embodied Drawing #5. Emotions—material resistance and thought-provoking expression.

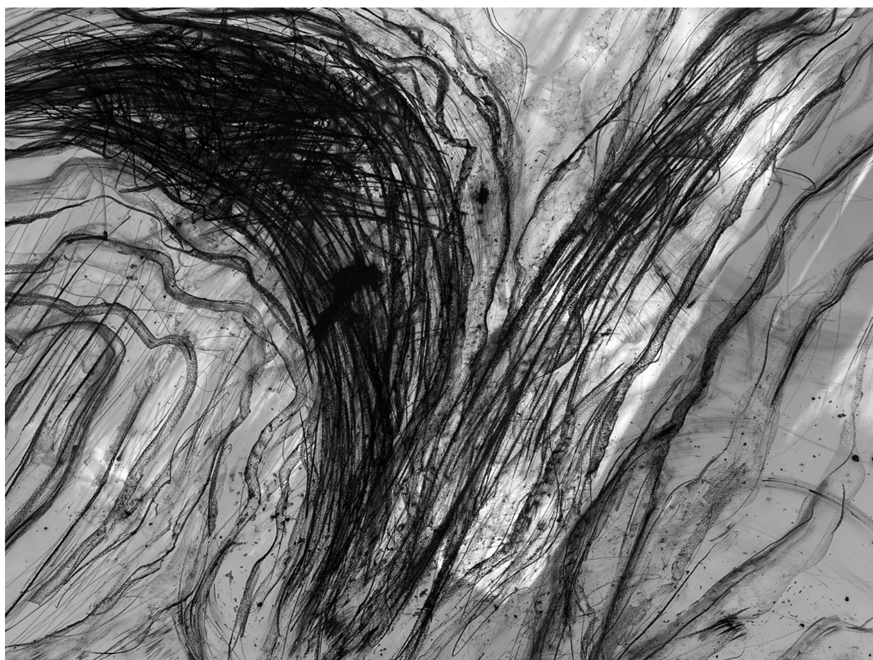

Figure 10.4 Embodied Drawing #8. An interruption—material flow—close to nature.

The paper moves back and forth while I move my body. I hear the river floating, the sound of my hand, my breath, and my body's rhythmic movements. Quickly, I consider how to continue working with the drawing. Then I am up and running again—completely engrossed in the process. I feel the positive effects of working with my body—something redemptive. Something new is emerging in the expression. I continue until dusk.

Embodied Drawing #5. Emotions—material resistance and thought provoking expression. During the process, I try to make an expression that is harmonic, but something else is expressed. I struggle with the composition and the drawing. I experience resistance—something disturbingly dark, emotional, and beautiful is expressed—fear may be that everything has an end.

Embodied Drawing #8. An interruption—material flow—close to nature. It is a windy day; the wind grabs the paper, and it blows towards me. I try to play along, but nothing is working. The wind thaws the paper on the ground. I am frustrated, but I try to be open to the process. I continue to draw on the paper on the snow-covered surface on the ground. Something interesting occurs. The substrate of the wood affects the texture of the lines and the shapes, and the melting snow affects how the paper absorbs charcoal—new marks are made on the surface. Impulses from the materials directly affect the drawing process; the material dissolves. I feel close to the materials and to nature. I am completely present in this process and draw for a long time.

Whole-body drawing involves risk; it is material, rhythmic, and temporal

Drawing is embodied. Drawing in large format in an outdoor environment is an invitation to directly engage with materials and space through bodily movement in a three-dimensional environment. In the making process of ED #1, it was very cold, and I experienced no time to hesitate. With charcoal in hand, I had to keep moving, trusting that my drawing was anchored in my bodily knowledge and movement. I became aware of how I used my whole body while working with my body's axis, moving my body and my arm in an arc from the top to the lower edge of the paper while standing with my legs wide and stable on the ground. I dropped into a steady rhythm and felt that I allowed myself to be immersed in the process. From time to time, I stopped and reflected upon the lines and marks I had made before I continued drawing. The lines became direct, dynamic, and powerful. I was a little surprised by the vivid expression that emerged, as it was in sharp contrast to the quiet and white surroundings—but I liked it. I was completely engrossed and present in the process.

In ED #2, I drew in slow movements. I made large, curved lines, and I drew in fast movements, making sharp, short lines. I worked with repetitive movements and felt that I was in flow with the materials and the surroundings. My thinking, in line with Newen et al. (2018), was embedded in the structures of the material surrounding me, my bodily movement, and the charcoal in my hand. While I drew on the hanging paper, I moved in rhythm with the sound of my breath and the surroundings, and the flowing river nearby became, in a

way, part of my movement and expression. It was me, my body, the charcoal, and the paper—I felt that I was one with the experience of drawing and the surrounding nature. This experience is underlined by Ingold (2013, pp. 127–31), who argues that drawing is temporal and, in many ways, closer to music and dance than to, e.g., photo and painting because drawing flows with time. During my drawing process, I experienced material flow, and the feeling of fluidity made me present. Whether there was a high or slow tempo in my movements, it did something with my senses and how I connected to the process and my surroundings. I was attentive to the material affordances and the materiality of the surroundings; I sensed the moment and became aware of my own movements with the surroundings and materials over a period.

Time is a central aspect of being deeply engaged through drawing and developing *sensitivity to the materiality* of the surroundings. In ED #1 and #2, my *senses* were sharpened, I felt excitement, and I had tremendous energy, feeling the presence of my whole body. In the processes following these two first drawings, I experienced another type of presence and contact with the temporality of the process. I was calmer, my breath was slower, and my energy level was lower; it was like I had established a connection with the place already. The expression in the drawing changed in the last two drawings—as if the dynamic organic lines were floating on the surface of the paper.

Whole-body drawing is a way to connect to the materials' pace and rhythm. Biesta (2017) describes that the material's pace slows us down and that material engagement through hands is "bound up with the pace set by the world" (pp. 79–80), and in this way, the world and the materials require that we connect and come into dialogue. I understand and experience this dialogue as being in line with Newen et al. (2018), both unconsciously and consciously, involving both tacit bodily knowledge and my reflection. Through the drawing process, I adjusted myself to the pace and rhythm of the material and commuted between improvisation, reflecting upon, and considering how to approach the drawing next.

In the process of, e.g., ED #8, I worked with *materials in transformation*. The environment and the weather directly affected the paper and charcoal, and challenged and interacted in the process. During the process, the paper was affected by wind, temperature, humidity, and my moving body. Paper is perishable and fragile, so I needed to give it my all but at the same time be careful not to destroy the paper.

During the drawing process, my thinking was extended beyond my body (see Newen et al., 2018) through the drawing tools, the materials I used, and the environment. Ingold describes how you "become what you draw: not in shape but in affect" through drawing-thinking (2013, p. 129). This underlines how persons are shaped by interaction with the environment, not just influenced by it: a knowledge fundamental for education. I understand drawing to be transformative (see Ingold, 2013, p. 129) in line with how learning is an internal and external process of transformation (Sawyer, 2014). I experienced success when I related to the drawings like an immediate expression of a reflection, as a cognitive movement. I understand the reflection through drawing to be sensorial and emotional.

The drawing process challenged and expanded my thinking. The outdoor workshop afforded an authentic, real-world environment and a way of exposing myself to a more unusual way of drawing. In this process, I had to relate to the premises of the surroundings, as they directly affected the materials and my drawing process. These experiences are in line with how Dewey (1934/2005) argues for the importance of material resistance in art experience. The materials and the environment gave me new impulses, such as in ED #8 when the wind tore down the paper I had hung in the trees and changed the conditions for my movements or when the snow melted on the surface of my drawing and I had to relate to the water blending with the charcoal.

Making sense of and connecting with the world is enabled through whole-body drawing

The whole-body drawing process in the forest made a tremendous impression on me, a feeling of connection, presence, and belonging that shaped and imprinted on me. As shown, making sense through whole-body drawings is a concrete experience in real time, where emotions, senses, movements, thinking, materials, and environment are connected within the same experience. While vision naturally is important in drawing, tactile and haptic sensory experiences are central to explore and connect. It is in line with how Noë (2006) describes a person's experience as a temporally extended process of skilful probing which "comprises mind and world" (p. 216). Biesta (2017, p. 79) describes the connection with the world through the work of the hands, like being in dialogue with what is real, what is material, what has its own integrity, its own pace, and its own rhythm.

Whole-body drawing in large formats involves movements to a great extent and provides an opportunity to perceive and express oneself in diverse and varied ways. According to Noë (2006, p. 1), "What we perceive is determined by what we do", and human senses are interrelated and fundamental to a person's ability to make sense of themselves in relation to their surroundings. I recognise emotions to be thoroughly integrated into embodied sense-making during the drawing process, which is in line with Thompson and Stapleton arguing that emotions and cognition are one unity and inseparable (2008, p. 26). My gut feelings guided my decision-making during the drawing processes, such as in ED #8. I experienced success with the drawings when I grasped the opportunities for action that were present in the situation and played along with the material affordances during the drawing process. I understand this kind of openness and embodied knowledge as central to the drawing process.

Implications for education

The most central element for teachers to consider regarding analogue drawing from an enactive perspective is the learner's encounters, movements, and

dialogue with different materials and environments. It is important that learners experience making different artistic expressions through the use of different (1) materials to draw with, such as charcoal, pencils, and pastels, and (2) materials to draw on, such as paper with different textures. Materials to draw with—such as charcoal—provide embodied knowing of materials' affordances, what they can do, how they respond, and which marks and expressions can be made with them. The surface—the material on which something is drawn—directly influences the mark-making, so it is also important for learners to experience mark-making on different materials with varied textures. Variation in materials to draw with and on invites learners to tangible and tactile experiences that digital technologies cannot yet offer. In addition, analogue drawing creates a presence that I argue is unique for material engagement (cf. Biesta, 2017; Schrøder, 2022).

Teachers should invite pupils to express themselves in varied and bodily ways in diverse types of formats and environments. Teachers can engage pupils in whole-body drawing by, for example, challenging them to draw outside on a windy day or drawing with charcoal inside while sitting or lying on the paper. In such an indoor exercise, the light can even be turned off because more important than the mark-making is the experience, the presence. It is vital for learners to experience such material engagement because it offers ongoing generative movement that is improvisational, spatiotemporal, and rhythmic—a process where the learner's embodied cognition is embedded in the structures of its material surroundings (Newen et al., 2018). In analogue drawing, the senses are involved in more complex ways than in digital drawing; an interruption of the traditional approach to drawing can also be an enriching experience.

Analogue and especially whole-body drawing involve risk-taking and a real-world experience that digital drawing cannot offer. In manual drawing, marks are made that are difficult to erase, and you must deal with them throughout the whole process. I experienced my drawing process to be open-ended and improvisational: trying, failing, reflecting, and, sometimes, succeeding. To not know what the outcome will be is a central part of a creative process such as drawing. It can create uncertainty to not know and must be practised to be mastered. The same applies to tolerating an explorative open-ended process: it is a way of exposing oneself that needs to be trained. I think it is necessary to focus on the joy of drawing and to think of it like play, exploration, and exercise in education. An example of such a task that I have carried out several times with students is "flying with friends". The exercise is inspired by Tom Marioni's drawing from 1999 with the same title. I use paper on a roll in large format and coloured markers, and the students perform the exercise in a large project room. In pairs, students "fly together" with markers on paper. The students decide how to solve the task—e.g., by fixing the paper on the wall or the floor, jumping, moving fast or slow, or running while drawing.

It is central that teachers think of drawing as a process that is joyful and about exploring, discovering, experiencing, thinking, and creating that involves

trying without knowing the outcome. Additionally, drawing is a way of being present, experiencing material flow, and being deeply engaged. I conclude by highlighting the importance of teachers being aware of the potentials of both analogue and digital drawing, and of how the ability to move in three-dimensional environments and drawing with large movements affects the learner's ability to create, unfold, and express.

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11 Apprenticeship as a model for teaching and learning in formal education

Camilla Groth

Introduction

Apprenticeship is often referred to as the raw model for teaching and learning—a form of situated learning that is based on transmitting practical but also contextual knowledge. In the field of professional crafts, learning has traditionally been organised in guilds and apprenticeships. These are social and material learning contexts that take place in a workshop setting in which novices are guided by a master craftsperson and a group of other practitioners at different levels of expertise. Drawing on my own experiences of being a potter's apprentice for three years at the age of 17–20, I see many benefits to informal learning, such as the situatedness of the learning, the enculturation that comes with the setting, and the real-time feedback from a master. Through a case of online teaching of a craft practice during the COVID-19 pandemic, I discuss the role that imitating and mimicking actions have and the role of showing as part of telling in learning a body-based practice, such as throwing clay on a potter's wheel.

Apprenticeships of different kinds have existed in the past as sometimes undemocratic and suppressive forms of forced labour, tainting the idea of apprenticeship learning. However, when well organised, apprenticeships facilitate a learner's active participation in their own learning through working on real-world tasks and problems that are contextualised and meaningful, and build on the learner's previous knowledge and skills. Additionally, the learner is a member of a larger practice community that supports the enculturation of habits and mindsets of the field. This gives an extended purpose to the activity and an arena in which the learner can articulate and reflect on their learning. In this way, the learning is deep and grounded, both in a psychophysical and social dimension. All of this is echoed in the central themes of the learning sciences (Sawyer, 2014, p. 4), which claim that "students learn deeper knowledge when they engage in activities that are similar to the everyday activities of professionals who work in a discipline" and that "the natural progression of learning starts with more concrete information and gradually becomes more abstract" (Sawyer, 2014, p. 11).

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While being the natural way for teaching and learning crafts for centuries, such informal education has given way to more systematic formal education, away from the authentic context of the practice field, away from its expert practitioners, and into school buildings and classrooms. This is more effective in many ways—more equal, democratic, structured, and controlled—but might miss the grounding of concepts in real-life contexts (Abrahamson & Lindgren, 2014; Kiefer & Trumpp, 2012). The domain of craft practice will serve as an example for discussions on how to reconnect teaching and learning to more situated forms in this chapter. Here recorded video materials or even online contact with a practitioner might bring some of the contextual and embodied aspects to the classroom.

Apprenticeship learning as understood through 4E theory

4E's grounding of cognition in embodiment, enaction, and embeddedness, and the extended mind is realised very concretely in craft practice and in apprenticeship models of teaching and learning. The *embodiment* of skills and knowledge means that they become second nature to the practitioner, and there is no need to think separately from doing—making is a form of *thinking through actions*, tools, things, and materials—or *thinging* (Malafouris, 2014). Thinking and imagination are *extended* through tool use (Baber, 2015), and skills and knowledge are *enacted* and *embedded* in the social and material context of the studio and other practitioners (Lave & Wenger, 1991). In informal learning situations, much practical know-how is transmitted through being in a situation of practising with others, during which learning happens not only through verbal instruction but through immersion and enculturation. Through mimicking, students gain new habits and gestures that are embodied and become part of the learner's identity. The learner is also guided in their own exploration of material affordances and how to adjust to material resistances.

Human-environment coupling and material engagement

Human-environment coupling and especially Gibson's (1986) visual ecology and theory of information pick-up as *affordances* have influenced the formation of 4E theory. Instead of leaning on a passive intake of information, humans and other organisms actively engage with the world to gain information. Simultaneously, organisms learn of their own bodily abilities in relation to the environment and objects in it. A chair affords sit-ability for a human but climb-ability for an ant. Similarly, in craft practice, engagement with materials relies on the person's understanding of what the materials and situation afford in relation to the skill levels of the person. A novice, like the girl in Figure 11.1, may experience that the material offers resistance or is challenging to handle before she learns how to angle the knife purposefully.

Figure 11.1 Craft practitioner Linda Lindblad shows Greta Lindblad-Jönsson "how to do it". Photograph by Helena Åberg.

Material resistance is thus experienced when material properties or the skills of the practitioner are stretched to the borderline. At the same time, this is also the sweet spot for learning, as repeated interaction with materials in this way builds experiential and embodied knowledge.

An attempt to describe such active engagement in relation to materials has been made by Malafouris (2018, p. 755) in his material engagement theory (MET): "Material engagement is the basic process by which we discover the feel and functions of our senses and through them the capacities, limits, and boundaries of our bodies". Material engagement also suggests a shared situational becoming that involves the maker, material, and tools, and the extension of the mind into the environment. As the child in Figure 11.1 uses the knife, her intention to create a flute is extended from the hand and via the tool to the material, the wood. The knife extends the girl's cognition, but her skills in using the knife also limit the actions possible.

Situated learning, enculturation, and cognitive apprenticeship

Unlike the classroom setting, a craft studio seldom offers situations in which an event is separated from its context, other practitioners, or the habits and attitudes that have formed around the type of event. Bourdieu (1977, pp. 78–9) writes about the *habitus* of practitioners, and the social background for any practice. The context of the studio and the *community of practice* (Lave & Wenger, 1991), grounds the practitioner in the community and enculturates

the learner that enters it. This means that the cognition of the practitioner is embedded in the social and material environment where the practice takes place or has its roots (Brown et al., 1989). Learning from experts in the field is important in this context and allows scaffolding (Reiser & Tabak, 2014) by following those who are more advanced, and thus learning in the *Zone of Proximal Development* (Vygotsky, 1978). Collins and Kapur (2014, see also Brown et al., 1989) extends the notion of apprenticeship learning to a "cognitive apprenticeship" that includes the generalising of knowledge that may be applied in other contexts. The six teaching methods associated with cognitive apprenticeship learning are Modelling, Coaching, Scaffolding, Articulation, Reflection, and Exploration (Collins & Kapur, 2014, p. 113–114); however, I would also add mimicking to this list.

Studio pedagogy: Show and tell!

Embodied cognition and experiential knowledge form the base of craft practice, but such knowledge is largely automated and, therefore, mostly tacit and, to some extent, unconscious (Groth, 2022). This means that many of the skills and attitudes taught and learned are not explicable in linguistic form. Instead, gestures and "pointing" ground the "show and tell" type of instruction, modelling, and enculturation in the apprenticeship model of learning and in studio pedagogy (Sawyer, 2018).

Master craftspersons are not always aware of their knowledge or might think of details as mundane, thus such aspects of the practice might not surface in a lecture room or in writing. Often, the knowledge is contextual and may not pertain to "general" examples. However, craft processes are time- and space-contingent activities that often rely on a certain path or trajectory to succeed. In the situation of *acting* or performing the practice, the task's constraints surface and are more readily explained by showing what, how, and when to do certain acts. Showing and telling through demonstrations and side-by-side hands-on activities facilitates both the articulation of craft knowledge and students' learning through mimicking and modelling the actions. Even the similar position of bodies helps in understanding which direction a movement is done, as seen in the same-way positioning of the child and crafts person in Figure 11.1.

Mimicking, embodied simulation, and gestures

Craft actions are simulated and eventually embodied by mimicking hand positions, pace, pressure, gestures, and body positioning. This bodily communication of skills and learning has allowed traditional craft skills to be passed down through generations. When mimicking someone's actions, Gallese (2019) suggests that it is possible to understand the physical and emotional intentions of others by internally simulating them. Embodied simulation has to do with how we react and align with each other in a kind of kinaesthetic empathy (Lehmann, 2012, p. 14). This builds on automatic and

even unconscious bodily contagion of actions and is quite different from what is normally meant by empathy. For example, the careful and respectful handling of a knife can be sensed by observing a master's careful use. Practitioners may not always be able to articulate important aspects of their embodied practice, but a novice may be able to sense and imitate the actions without verbal instruction.

Gestures and the role of bodily habitus and ways of acting with a material play a large role in this context. Gestures are seen as the embodiment of thought (Härkki, 2018; Hostetter & Alibali, 2008). A teacher or a crafts expert who is invited into the classroom can silently show someone how to do something by concretely moving their hands and showing the correct movements as a visual gesture or in a direct physical "hands-on" showing (see also Groth et al., 2013). In the next section, I show an example of teaching a material skill, the art of throwing clay on a potter's wheel, in an online video setting. The example shows how visual gestures may help a student to mimic movements in real-time even through a screen, when real-life tactile guidance is not available. Through this, I wish to introduce the idea of bringing more contextualised content from the studio into the classroom through online communication with external experts.

Teaching and learning through bodily guidance

Visual gestures and active feedback

I will now show an example of how I taught higher education students clay throwing by showing craft gestures that the students could mimic via Zoom, as I was not able to visit the campus during the COVID-19 pandemic. As a teacher in arts and crafts in the spring of 2021, I was faced with the task of teaching a group of 13 bachelor students clay throwing on the potter's wheel at a campus in Norway. The campus had just re-opened for students after a lockdown, but travelling was still not recommended, and I was not able to get to the campus. The only way to engage with them was online, which I did through individual teaching sessions on Zoom. As a pre-task, I asked them to watch YouTube tutorials of clay throwing and a purpose-made video tutorial that I had prepared in my studio of how to throw a basic cylinder on the potter's wheel.

Each student was given a 45-minute session in a schedule over three days. The students were asked to use a computer or tablet that they could place in front of them by the throwing wheel in the clay studio so that they could have a Zoom meeting with me while they were throwing clay on the wheel in a synchronous teaching and learning situation. The Zoom sessions were also recorded. During the sessions, I noticed that I was gesturing a lot while talking, and I started collecting screenshots of the gestures I had made from the recorded videos (see Figure 11.2).

It surprised me how "embodied" the situation of guiding the students was, even though we engaged in the practice through a screen and not through

Figure 11.2 Screenshots from the recorded online teaching session by the author.

being physically present. The individual Zoom sessions with the students allowed me not only to follow their actions with the material in real-time and to give them direct feedback on their actions—it also allowed me to show the hand movements and procedures through gestures that they could mimic. The feedback from the students was that they were pleased with having such individual feedback on their actions for a longer time, and they felt that they had the possibility to ask questions and try out new techniques while being guided through insecure moments in the throwing practice. This shows that a sense of participatory guiding, including real-time and relevant feedback on actions, was possible even in a long-distance setting. As the sessions were recorded and sent individually to the students, they were able to return to the sessions and watch in slow motion to repeat important actions in their processes. While physical guiding in real materials is naturally preferred, and before the pandemic, I'd never recommended such a way for guiding students, I now think that this way of engaging external experts—either live or through pre-recorded media—can help bring in the context of learning situations into the classroom when real physical presence is not possible.

Facilitating apprenticeship learning in the classroom

While arguing for apprenticeship learning in formal learning settings, the reality is challenging in today's schools. Many more subjects are taught now than

when people were learning crafts in the home environment or the professional workshop, and few teachers are experts in all areas. This means that only a few specialised subjects or skills can be taught in an experiential manner. Large student group sizes are also problematic as apprenticeship requires close and attentive teaching through participatory instruction (Collins & Kapur, 2014). One way to expose students to authentic practitioners is to invite experts into the classroom to "show and tell" with the group. As this is an expensive way of exposing students to experts, a way to mitigate costs is to at least show audio-visual references and the context for crafts through video documentation of the practice and practitioners. The aspect of embodied simulation is also effective when mediated in audio-visual media (Gallese, 2019). As the use of video tutorials has grown rapidly due to the internet and YouTube, there is great potential in using videos for contextualising craft situations, even in school environments, utilising the effects of embodied simulation.

Nielsen (2009/2019) writes that *learning by doing*, as proposed by John Dewey in the 1930s, is important in the field, but that this can be combined with the concept of *learning by watching*. Nielsen suggests that schools can use digital learning resources such as videos when teaching students how to knit (Nielsen, 2009/2019, p. 37). She further writes that in this way, the video can be shown repeatedly, and the teacher's time can be spent with those students who need concrete help. As shown earlier (see Figure 11.1), mimicking relies on vision and the possibility of acting in real-time with the expert practitioner, modelling their actions. When hands-on contact teaching is not possible, the visual aspect of a craft action can be facilitated through forms of visual media. Audio-visual recordings capture and document aspects of craft practice in ways that are not possible through writing, such as sequences of activities, their order, pace, rhythm, or the sounds of the tools in contact with the material. Even the haptic dimension can be inferred by audio-visual connotations through our pseudo-haptic understanding (Pusch & Lécuyer, 2011); that is, the *imagined* sense of touch that we may recall from previous similar experiences.

Implications for education

While just viewing a video doesn't involve any actions on the student's part, it is possible to combine it with practical try-outs in material. In such cases real-life feedback on the students' actions still needs to be given by the teacher. However, bringing the master into the classroom—even in an audio-visual format—exposes the students to the habitus and culture of the practice and lets them study under the influence of those in a more situated way that is normally not possible in formal education.

Students can engage with the video of the practice repeatedly, rewinding and fast-forwarding—something that they wouldn't be able to do in a real-time session. They may also find the answer to their question faster than waiting for the assistance of their teachers in the classroom. Many schools have

invested in 1:1 touchscreen devices and tablets, and through these, the students may follow a master practitioner in video tutorials, individually and at their own pace.

Grounding students' learning experience in material engagement, as well as making meaningful connections to the culture and situation of that practice, gives new dimensions to the experiences and might help students' motivation and active initiatives. YouTube and other social media sites provide endless resources for tutorials; school-aged children already use these sites to seek quick answers on how to do something. As teachers, it is necessary to take this dimension of the students' personal learning environment into account—teachers are no longer the sole owners of knowledge or authorities of best practices (Dietrich et al., 2020). Multimodal learning experiences (Fors, 2013; Fors et al., 2013) and video pedagogy (Gedera & Zalipour, 2021; Pink et al., 2016) are already recognised means for bringing about an embodied dimension into otherwise static and disconnected study forms (see also Abrahamson & Lindgren, 2014, p. 365). Computer technology is advancing towards simulation environments that take the idea of situated learning into the realm of expanded realities, seen by many as the future of education.

Several researchers consider that audio-visual media will grow into the dominant teaching medium on the internet and will become a standard part of education (Laaser & Toloza, 2017). Video plays an important role, especially in Massive Open Online Courses (MOOCs), and is also used for practice-based demonstrations (tutorials) in both formal and informal contexts (Bétrancourt & Benetos, 2018). YouTube is the most used resource for instructional videos generally, and even very young students know how to access these. However, to align the content with the desired context, subject matter, and student level, the challenge is to create the right type of video tutorials (Guo et al., 2014). The right content should also be combined with a pedagogical process that advances the intended learning objectives. For example, in my own setting, I asked the students to first watch YouTube videos and then a purpose-made video, and after this, we had the online session that was recorded and sent to them for later reflection. While ideally, the environmental context of a studio setting could also have been conveyed better, this was not possible at the time of the pandemic but could be enhanced in the future. Utilising multimodal media for learning purposes can be applied to any physical practice, as they allow for modelling, coaching, and scaffolding, as well as making tacit dimensions visible and more readily analysed and articulated.

Conclusions

Apprentice learning facilitates active participation in learning through working on real-world tasks and problems that are contextualised and meaningful, and build on the learner's previous knowledge and skills. Facilitating informal learning models in formal settings is challenging due to numerous topics and

large group sizes. While visiting studios and experiencing practices and materials in their contexts would be preferable, bringing experts to the students in an audio-visual form may help convey the context and situatedness of the practice. Carefully selected videos bring the world into the classroom and give a multimodal dimension to the studied practice, even at a distance.

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Part V

Technology, nature-connectedness, and science learning

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12 Conceptualising technology-enhanced embodied pedagogy

Satu-Maarit Korte and Minna Körkkö

Introduction

Learning and human cognition are holistic embodied activities in which the physical body, interactions with the social and cultural environment, and sensory and motor experiences are intertwined (Frangou & Körkkö, 2020; Sullivan, 2018). Body-mind integration in technology-mediated learning refers to the use of technology to engage both the physical and mental aspects of a learner, promoting a holistic and immersive learning experience. For example, virtual reality for learning anatomy through exploring 3D models of the human body can incorporate haptic feedback devices such as gloves or vests to stimulate the mind (cognitive understanding) and body (sensory input).

The advancement of digital technologies has significantly impacted our social, political, and cultural domains, increasing the need to integrate technologies into pedagogical practices at all levels of education. Some studies have shown considerable benefits of incorporating embodied perspectives into technology-enhanced learning environments in the contexts of special education, languages, STEM (science, technology, engineering, and mathematics), and STEAM (science, technology, engineering, arts, and mathematics) education in elementary and middle school (Kosmas & Zaphiris, 2023; Lindgren et al., 2016; Xu & Ke, 2020).

In what follows, we first look at the learning experience (LX) design experiment (Georgiou & Ioannou, 2021), which is, so far, the only technology-enabled embodied learning design experiment derived from the 4E embodied cognition framework. We have included it in this chapter specifically because it offers empirical evidence and has a perspective on learning as a cognitive, kinaesthetic, and socio-emotional process. Second, we examine the framework for technology-enabled embodied learning environments (TEELEs) by Xu et al. (2021), in which the concepts of presence, immersion, and agency overlap through physical, sensory, and cognitive features in learning. The TEELE framework was chosen in this chapter for its unique view on embodied immersion and how it embodies technology use by providing valuable practical directions. Third, we look into the model of technology-enhanced

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affective learning (Frangou & Körkkö, 2020), which sees cognition as a socio-emotional process interlaced with cultural, ethical, and cognitive aspects. This model strengthens the theoretical background of this chapter. By merging the three models' common fundamental practice-oriented principles, we offer a new model for technology-enhanced embodied pedagogy as a practical tool for teachers wishing to create holistic, technology-enabled learning experiences.

Learning experience design and technology-enabled embodied learning environment frameworks

In this paper, we build on socio-constructivist and sociocultural perspectives on learning (Lave & Wenger, 1991; Vygotsky, 1978). We understand learning to be constructed upon existing knowledge and connected to all activities inside and outside the learner, hence encompassing sociocultural contexts and artefacts, and taking into account the learner as a whole. Therefore, learning is a situated activity that involves social and cognitive processes, leading learners to participate in their community's sociocultural practices (Lave & Wenger, 1991). This view is in line with the 4E cognition framework, in which embodied learning is defined as encompassing four elements (Lund et al., 2019; Newen et al., 2018):

a Embodied learning (i.e., learning is a cognitive and bodily process)
b Enactive learning (i.e., learning is active and interactive)
c Extended learning (i.e., learning can occur with and through a medium)
d Embedded learning (i.e., learning occurs within physical and sociocultural learning environments)

Learning experience design

The 4E elements (embodied, enactive, extended, and embedded learning) form the basis of the LX design experiment by Georgiou and Ioannou (2021). The study aimed to determine how teachers and students perceived the LX design and how it impacted students' engagement and subsequent conceptual learning gains regarding geometry (angles). The LX design was implemented and evaluated by eight primary school teachers in Cyprus as part of the mathematics curriculum in 13 primary education classrooms in eight schools, with 213 students from the third to fifth grades (ages 8–10).

The experiment included four learning stations: two incorporated technology, while the other two had paper, pencils, and traditional mathematics props. The technology used included the Kinect-based angle-maker (see Figure 12.1) embodied learning application projected onto a screen, and Bee-Bot and Blue-Bot floor robots (see Figure 12.2) coded to make predefined angles in their movements. The angle-maker is a noncommercial application that uses the

Figure 12.1 Kinect-based angle calculations are made by looking at the human body's different angles. Photograph by Satu-Maarit Korte.

Kinect camera—a line-of-motion sensing device—to track students' arm movements and create a visual representation of body movements on the screen (Georgiou & Ioannou, 2021).

Bee-Bot and Blue-Bot (see Figure 12.2) are floor robots that are programmable from the six directional keys on their "backs" to make up to a 40-command code, according to which the robot moves; Bee-Bot is often used for teaching computational thinking to children (Angeli & Valanides, 2020). Blue-Bot has the same function keys, but it is transparent so that its hardware is visible, and it can also be connected to and programmed through a mobile application via Bluetooth.

The LX design learning experiment (Georgiou & Ioannou, 2021) lasted 80 minutes; students were divided into mixed-ability groups of four to five students in the same grade. At the technology-enhanced learning stations (angle-maker and floor robots), the students took turns using technology to learn geometry while the other students provided feedback and support. The study

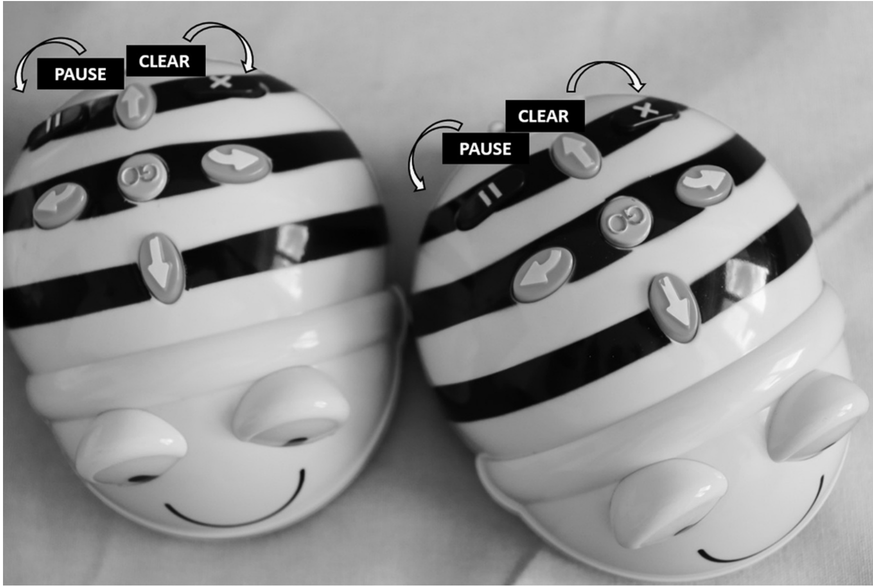

Figure 12.2 Bee-Bot floor robots. Photograph by Satu-Maarit Korte.

data was collected through students' appraisals of the LX design, their pre- and post-conceptual tests consisting of five mathematical tasks involving angles, student engagement surveys (cognitive, emotional, and social engagement), and teachers' interviews after the intervention.

The students especially appreciated the kinaesthetic nature of the angle-maker and, thus, the possibility of integrating moves and gestures into the learning content. When evaluating the LX design, the students made positive statements related to the use of robotics and the game-based approach that guided the design of the learning stations. The students also appreciated working collaboratively and using technology, computers, and tablets to programme the Bee-Bot/Blue-Bot floor robots. The students mentioned positive emotions experienced during the intervention, most commonly enjoyment and excitement. The students felt that the learning experiment had improved their conceptual understanding of angles, as well as their digital skills. The LX design also enhanced the students' positive attitudes towards learning mathematics.

The teachers shared similar thoughts: They found the experiment contributed positively to the students' knowledge acquisition, conceptual understanding, digital skills, engagement and motivation, collaboration, and communication. The teachers related the increase in students' knowledge acquisition to features of the embodied learning application that allowed diverse bodily involvement, the use of multiple senses (sight, touch, and hearing), the visualisation of abstract concepts, and real-time feedback (such as

hints). Increases in student engagement and motivation were similarly related to the application, especially its playfulness, the novelty of the learning approach, and the application's immersive and user-friendly interface. Students' collaboration and communication skills improved significantly because of the structure of the LX design, facilitating teamwork and support for each other at learning stations.

This LX design experiment was planned around the 4E elements. Embodied learning is integrated into the LX design through the involvement of the body in the cognitive process with the bodily movements of the limbs, facilitated by the angle-maker application. Enactive learning is manifested through the interactive features of the intervention, as well as the active features of the angle-maker application. Extended learning can be seen in that learning occurs with and through the medium of the angle-maker application. Finally, embedded learning is an integral part of the intervention because learning occurs within both physical and interactive sociocultural learning environments, where angles are understood to exist everywhere.

Embodied immersion framework

TEELEs, and their salient potential for embodied features in learning designs, were investigated by Xu et al. (2021). Their review article on 28 empirical studies of TEELEs formed the foundation for the development of an embodied immersion framework. Most of the studies involved science and language learning, and they were conducted at all levels of education. The framework seeks to understand the features of embodiment and conceptualise how to embody technology use by providing valuable practical directions. The embodied immersion framework stems from the sometimes overlapping concepts of presence, immersion and agency, and has three major dimensions: physical, sensory, and cognitive immersion (Xu et al., 2021). Presence can be seen as the psychological sense of consciousness and response to the technology-enhanced learning environment, whereas immersion or engagement can be considered the illusion of reality projected by the affective properties of the technological hardware (Calleja, 2014). Agency is essential because it gives the technology user (i.e., the learner) a role in shaping the learning experience (Calleja, 2014). The three dimensions of the framework with their eight additional subdimensions are as follows (Xu et al., 2021):

1 Physical immersion: the means of embodiment and the number of motoric movements

   The physical immersion dimension (Xu et al., 2021) first entails the means or medium of technology-enabled embodiment. Furthermore, in an embodied technology-enabled interactive scenario, the user can be either a passive observer or an active agent, interacting with the learning material and moving their body in the process. One can also view and evaluate the

number of bodily or motoric movements to define the intensity of the embodied interactions, from mouse clicks to full-body movements. In this dimension, all of the 4E framework's elements are recognisable. Embodied learning includes motoric body movements, whereas enactive learning involves activity, interactivity, and observing activity, which is passive embodiment. Extended learning occurs in TEELEs with and through a technological medium. Learning is embedded because it takes place in a certain physical environment.

2 Sensory immersion: point of view, media effects, and haptic effects

The sensory immersion dimension is subjective and, hence, more difficult to define. It is important to understand the user's point of view and perspective within the technology-enhanced learning environment. Immersive experiences offered by a learning environment that is perceived from the point of view of the first or third person can be very different. Moreover, media effects—namely, audio (music, voice, and sound effects) and video (animated or static images, videos, and texts) qualities—are significant affordances within the immersive learning environment that may enhance the sense of immersion. The haptic effect refers to the learner's ability to sense or feel their learning surroundings and receive haptic sensations, which contribute to the learner's cognitive processes as they become more involved in the activity and gain a multidimensional understanding of the learning subject. All the elements of the 4E framework are also recognisable in this dimension. Embodied learning occurs through bodily sensations; this requires that a person is actively present in the embedded learning environment in which the learning is organised with and through a technological medium.

3 Cognitive immersion: operational congruence, learning congruence, and personalisation

According to Xu et al. (2021), cognitive immersion is the bridge between the learning process and a technology-enhanced or technology-enabled immersive experience. Within cognitive immersion, motoric activities may serve operational purposes; however, in some experiments, operational congruence is higher than in others because embodied interactions are linked to operational purposes. Learning congruence, on the other hand, links embodied interactions and motoric activities with learning objectives. Some emerging learning technologies are adaptive and support personalisation based on the learner's developing abilities. This is still a growing area of research, an area Xu et al. (2021) considered critical for developing personalised learning paths that scaffold learning and enhance learners' engagement. This third dimension of the TEELEs framework is in line with the elements of the 4E framework in that embodied interactions are part of the basis of learning congruence. Learning takes place with and through a technological medium that defines the physical learning environment.

Model of technology-enhanced affective learning

The model of technology-enhanced affective learning (Frangou & Körkkö, 2020) views learning as enhanced through four core elements that are important when designing affective learning experiences: *engagement*, *elaboration*, *encouragement*, and *exploration*. *Engagement* refers to the fact that an increase in learning engagement, in which technology can play a significant role, may improve learning achievements. This can simultaneously develop the learners' agency, and positive and negative learning experiences can influence the learner's future disposition and motivation for learning.

Offering opportunities to *elaborate* on and expand positive learning experiences ensures that learners are eager to return to class. Sharing, reflecting, and *elaborating* on positive experiences are significant for promoting learning motivation.

Encouragement builds learners' self-perceptions and supports their agency, as well as the general development of the learning atmosphere. The learner's emotions and understanding of their abilities and competencies can inhibit or increase their motivation to take part in the learning activities. Sensitising learners to diverse technologies and *encouraging* them to try new ones later is good for their self-confidence and self-perception while also promoting lifelong learning.

Exploring group members' different perspectives and social and cultural backgrounds enhances learners' reflective practices and, consequently, their sensitivity to situational awareness. To support these elements, the maintenance and improvement of a positive and dialogical social learning environment is continuously facilitated. *Exploring* diversity can connect the learner not only to the learning experiment but also to fellow learners, creating a positive learning environment.

The element of engagement correlates with the dimensions of the 4E framework by involving cognitive and bodily processes in an active and interactive learning environment. The physical and sociocultural learning environment is designed to take advantage of technological mediums, possibly embodied, that have the potential to enhance engagement and motivation. At the same time, the element of elaboration is an active and interactive process that can be seen in the 4E framework as an activity in which learners can be both alone and with others. Elaboration can also be done with and through technological mediums in diverse physical and sociocultural learning environments. The element of encouragement can be seen in learning as both enactive and extended, as per the 4E framework: learning is active and interactive, and it can occur with and through a medium. The element of exploration is recognisable in the 4E framework, particularly in enactive and embedded learning. This involves active and interactive learning, which occurs within physical and sociocultural learning environments.

In what follows, by merging the aforementioned three frameworks' common and fundamental practice-oriented principles, we offer a new model for

technology-enhanced embodied pedagogy as a practical tool for teachers wishing to create holistic, technology-enabled learning experiences.

Technology-enhanced embodied pedagogy

Given the diversity of the models discussed earlier (Frangou & Körkkö, 2020; Georgiou & Ioannou, 2021; Xu et al., 2021), it is essential to focus on their common features. The LX design experiment (Georgiou & Ioannou, 2021) highlights selecting embodied applications that enable the integration of the physical body, motion and cognition, and a learning approach based on student collaboration. Conceptual understanding is promoted by guiding students to work through conceptually connected learning stations or other modules. It is assumed that immediate feedback and peer feedback may play a role in motivation and learning outcomes (Georgiou & Ioannou, 2021). The TEELEs (Xu et al., 2021) framework has three dimensions of immersion—physical, sensory, and cognitive—which are all essential when promoting immersiveness together with all eight subdimensions of immersion. The model of technology-enhanced affective learning (Frangou & Körkkö, 2020) illustrates the core elements that are important when designing affective learning experiences: engagement, elaboration, encouragement, and exploration.

Figure 12.3 shows the essential elements of technology-enhanced pedagogy based on the principles that summarise the key features of the three

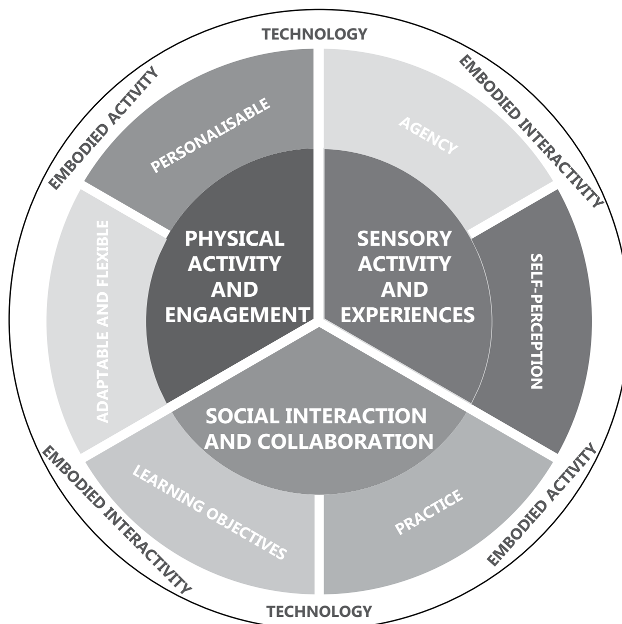

Figure 12.3 Technology-enhanced embodied pedagogy.

discussed models. First, as the figure's fundamental principle (background circle of Figure 12.3), learning involves diverse *technologies* and exposure to technologies (e.g., angles are investigated with the help of a Kinect-based angle-maker application, and computational thinking and coding can be taught through Microsoft Minecraft Education Edition and LEGO robot building and programming). As a result, technology and media are integrated into the learning environment and/or context. Therefore, the learning environment promotes *embodied activity and interactivity* (e.g., the use of an angle-maker application as a group activity and the use of makerspaces, such as arts and crafts rooms).

Second, both the LX design (Georgiou & Ioannou, 2021) and the TEELEs (Xu et al., 2021) framework emphasise physical features (inner circle of Figure 12.3). Hence, learning involves *physical activity and engagement* (e.g., the Kinect-based PanBoy application for language learning or the Kinems learning games). It would be optimal if the learning were *personalisable*, *adaptable*, and *flexible* (outer circle of Figure 12.3) (Xu et al., 2021) to support the *elaboration* (Frangou & Körkkö, 2020) on and expansion of positive learning experiences.

Third, learning involves *social interaction and collaboration* (inner circle of Figure 12.3) (e.g., collaborative Bee-Bot game-making or QR code navigation exercises in small groups) as per the LX design experiment (Georgiou & Ioannou, 2021) and the model of technology-enhanced affective learning (Frangou & Körkkö, 2020). Learning is linked to *learning objectives* and *practice* (outer circle of Figure 12.3) (e.g., Bee-Bot game-testing in groups, Kinems learning games, or visiting each other's Minecraft worlds) (Xu et al., 2021) while at the same time supporting the *exploring* (Frangou & Körkkö, 2020) of different perspectives.

Fourth, learning involves *sensory activity and experiences* (inner circle of Figure 12.3) (Xu et al., 2021) and *elaborates positive experiences* and *emotions* (e.g., Kinect-based applications, using a drawing application on a tablet computer or Kinems learning games) (Frangou & Körkkö, 2020; Georgiou & Ioannou, 2021). Learning promotes and *encourages agency* and *self-perception* (outer circle of Figure 12.3) (e.g., personalisable applications for learning in which the exercises become gradually more demanding) (Frangou & Körkkö, 2020; Xu et al., 2021).

The elements of the 4E framework are integrated and present in each of the model's principles, depending on the context and situation.

Embodied learning relies on the premise that knowledge is constructed by intertwining experiences, perceptions, bodily activity, and the body's sensorimotor capacities (Nathan, 2021). The principles of technology-enhanced embodied pedagogy are derived from the idea that the learning process is a holistic and multimodal activity (Frangou & Körkkö, 2020); however, to create technology-enhanced embodied learning activities, not all principles are always—or can be—present. In this chapter, we have looked into three frameworks that embrace embodied learning experiences and give some guidelines

for the introduction of technology-enhanced embodied learning (Georgiou & Ioannou, 2021). In all three, we have focused on the common embodied learning features and subsequently brought them together to develop the practical pedagogical principles that teachers can apply in diverse teaching.

Technology-enhanced embodied pedagogy is an educational approach that combines technology with embodied learning experiences to enhance the learning process. The strengths of the model include its generalisability; it can be applied at all educational levels. Furthermore, it can make learning more engaging and interactive. It can capture learners' attention and motivate them to participate actively in the learning process. It provides opportunities for experiential learning and multisensory learning, which can enhance the retention and understanding of complex topics. Technology allows for the customisation of learning experiences, catering to individual learning styles and pacing. Technology can also provide immediate feedback, allowing learners to correct mistakes and reinforce their understanding in real time.

However, the model has some weaknesses. Implementing technology-enhanced embodied pedagogy can be expensive. The cost of hardware, software, and training can be a significant barrier, particularly for resource-constrained educational institutions. Furthermore, technical problems—such as software glitches or hardware malfunctions—can disrupt the learning process and frustrate both educators and learners, particularly those who are not tech-savvy. Also, not all students have equal access to technology, creating a digital divide. Those without access to the necessary devices or reliable internet connection may be left at a disadvantage. Additionally, using technology often involves collecting and analysing data, which raises privacy and ethical concerns about how that data is used and protected.

Implications for education

This chapter has provided instructional strategies within technology-enhanced embodied learning design by offering examples of technology-mediated activity-based interventions that are adaptable and usable in any classroom. Technology-enhanced embodied pedagogy is important as it offers a unique approach to education that leverages technology to enhance the learning process through embodied experiences. Furthermore, it can enhance engagement, improve learning outcomes, promote inclusivity, prepare students for the digital world, and encourage innovation in education. This chapter provides a reference for practitioners who seek to design technology-mediated learning experiences that link movement and learning objectives. However, we acknowledge that, in many cases, educational technology or tools are neither necessary nor accessible. The teacher can still take advantage of the embodied learning approach with non-digital media or even without any media at all. In conclusion, technology-enhanced embodied pedagogy offers a dynamic and effective approach to teaching and learning that aligns with the evolving needs of learners and the demands of the 21st century.

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13 Smart technology in nature-based learning

Embodied and situated processes

Gertrud Lynge Esbensen, Theresa Schilhab, and Gitte Balling

Introduction

Smartphones are a promising new technology in the field of outdoor education; they continue to offer new possibilities for nature-based learning (Chawla, 2018; Esbensen, 2020), such as the use of nature apps, web access, and the ability to have a camera, notebook, and audio recorder at hand. Here, we explore the extent to which this potential is realised by presenting and discussing a case where smartphones are involved in pupils' embodied learning processes. We are particularly interested in the domain of curiosity-driven, knowledge-seeking processes, which includes derived documentation and storage activities. The case concerns a planned lesson developed for a class of fourth graders (around 10 years old) outside the school classroom and delivered by a nature guide. The lesson is described through an interview conducted by the first and second authors as part of the Danish Natural Technology project.

We are inspired by Lave's social practice theory. Lave focuses on how learners learn contextually, both physically and in situated ways in social communities of practice, as opposed to learning as decontextualised, classroom-based mental and intentional activities (Lave, 2019). Thus, the focus is on the authentic, social, and relational aspects of learning. Similarly, the 4E perspective, based on embodied cognition theory, emphasises that we perceive and experience the world from a situated point of view—and therefore understand the world individually based on prior knowledge, conditions, and experiences (Klomberg et al., 2022). The situatedness of learning is expressed in different aspects of a learning episode. For example, feeling tired, hungry, cold, or frustrated may engage us differently in learning processes compared to feeling comfortable and well rested (Schilhab & Esbensen, 2019, 2021; Schilhab et al., 2022). Basic perceptions also include structures of privilege—gender, socioeconomic status, age, literacy, different dispositions, etc.—which affect how we engage in learning processes (Holland & Lave, 2001). We see this embodied perspective in relation to Lave's (2019) argument that teachers need to acknowledge that learning processes are also about collective identity-making in the group

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through practices. We negotiate our embodied and social positions in communities of practice as we are positioned by others, and in this way, we learn to see others and ourselves as more or less social, skilled, wise, outdoorsy, etc., through the communities of practice we engage in throughout our lives (Holland et al., 1998; Holland & Lave, 2001). We, therefore, explore how familiar strategies for learning science can be complemented by these perspectives.

Social practice theory emphasises that we learn as we participate in socially situated practices and that both the practices and our participation in them change and develop dynamically (Lave, 2019). This resonates with 4E's view of cognition as enacted and dynamic; bodies are constantly experiencing and learning, simultaneously building on and adapting to prior knowledge. In line with social practice theory, cognition as embedded emphasises that learning is conditioned by particular physical and social environments. Both our physical and social environments can feel safe or unsafe, allow for play or seriousness, be perceived as boring or exciting, etc. (Schilhab et al., 2022). Thus, both perspectives see learning as a phenomenon that occurs far beyond intentional teaching processes.

This notion of learning activities resonates with cognition as extended. Insofar as practices and tools help by externalising thinking through the use of materialities such as maps, photographs, notepads, computers, road signs, and other forms of written language, they allow us to both store information and learn from past voices (Hutchins, 1996). Many of these learning processes are invisible, but they expose pupils to nature, scaffold their experiences of nature, and thus their motivation to engage with nature.

Next, we explain the learning processes facilitated by a teacher's plan in light of the 4Es described earlier and situated learning. We argue that smartphones can enable new child-led connections with nature as pupils learn to actively use their phones to stimulate curiosity about the natural environment. Thus, we also argue for a greater focus on the benefits of situated and embodied learning through the use of smartphones to teach pupils to be active and curious knowledge seekers.

The emerging fields of nature-based learning (Jordan & Chawla, 2019) and embodied learning experiences are part of a larger explanatory model of the decline in children's outdoor lives and, by extension, their experiences of nature (see, for example, Dickinson, 2013). Human-nature relationships are highly complex because they involve fundamental assumptions about how we understand and see the world and our role in it, as well as the different conditions and positions that frame our perceptions. It is therefore relevant to examine the common rationale that children in the past experienced a deeper connection with nature that has now been lost due to contemporary sedentary, indoor, screen-mediated lives. In doing so, we highlight the relatively rapid change that has taken place and consider how the challenges of digitalisation can be met by using technology to enhance rather than diminish children's connections with nature.

Societal changes and lost experiences with nature

In 1993, Pyle described the decline in children's contact with nature as an "extinction of experience" and expressed concern about the connectedness and stewardship of future generations if they do not build strong experiences of nature in childhood (Pyle, 2003). However, the conditions for children to be outdoors have always been influenced by structural conditions and adult values, which are dynamic. Therefore, the conditions for children's outdoor lives vary greatly between families, neighbourhoods, nations, etc., and it is, therefore, too much to say that children in the past generally had strong connections with nature.

In peasant society, children worked and followed the adults out into the countryside, so experiencing nature was a natural norm of everyday life (Frykman & Löfgren, 1983). The development of science and technology in the nineteenth century led to the division of human life into opposing worlds: home versus the outside world, and work versus leisure. First with urbanisation and then with the increase in the number of cars in the 1960s, road traffic accidents involving children increased as safe places to play became scarce (Karsten, 2005). Thus, whereas childhood used to be spent outdoors to a large extent, much of children's everyday physical and sensory experiences of the outdoors have been replaced, for safety reasons, by an indoor life supplemented by supervised outdoor time in gardens, schoolyards, and playgrounds designed by adults. It is, therefore, important to explore the potential of physical, curiosity-driven, nature-based learning to motivate today's children to develop relationships with nature.

Case: Technology involved meaningful activities

This case is based on an interview with Kristian, an experienced senior nature guide from a nature school that offers nature-based lessons to schools in the municipality. He is experimenting with allowing pupils to use mobile phones in the exploration processes of his lessons. A class of fourth graders will visit the nature school the following week, and Kristian (personal communication, 2018) explains his ideas:

> I encourage them to use their smartphones—camera and video recorder—to take pictures and make short nature films, if I can motivate them to do so. Their task will be to take pictures in the forest to document the season. What happens in the forest in December? They will take pictures and make short 20-second clips of what they find interesting in the forest at the moment. I then add an identification task by having them use the iNaturalist app to categorise their findings. The purpose is to let them discover how the phone supports their learning. My main aim is to make them curious—that they have access to a lot of knowledge in their pocket—and instead of being passive consumers of digital media, I encourage them to be active producers.

The pupils are to explore the woods around the nature school and select and record their findings. Note Kristian's caveat, "[I]f I can motivate them to do it", indicating both that the picture/recording may fail if the pupils aren't motivated and that the plant identification requires cooperative, disciplined, and motivated pupils.

We analyse the potential learning processes that Kristian's lesson facilitates when it works—theoretically. Note that these may not be easy to observe. The pupils have already learned various cultural codes of behaviour on class trips and in the forest, and these are already embodied and not visible until someone breaks the rules—e.g., by littering in nature or damaging living branches. Also, in the field, practical aspects may interfere with the expected learning outcomes—e.g., some pupils may be unfocused, and some phones may be out of battery. Therefore, in our analysis, we stick to the embodied and situated learning processes that Kristian's plan facilitates; that is, what, in his experience, usually works. Before moving on to the analysis, we will introduce the app used in the lesson.

The Seek by iNaturalist app

To perform plant identification tasks, the user must install the Seek app, open the app, press the camera icon, and point the phone's camera at wild plants, animals, or fungi. The app then scans the contents of the preview and attempts to identify the image using seven main taxonomic ranks (kingdom, phylum, class, order, family, genus, and species) (iNaturalist, 2020). Seek can be used for educational purposes and has a game-like motivation built in so that users earn badges as they continue to identify species with the app (see Figure 13.1). The identification feature is based on image recognition technology, and the species are based on photos and identifications made by the iNaturalist community. The system "learns" as it is used, so results may not always be correct. This means, first and foremost, that it is important to teach pupils to think critically. The app supports critical evaluation and deals with ambiguity by stating that the identification is inconclusive and by listing relevant matches to encourage users to compare and judge for themselves. By using the app without any knowledge of plants, animals, and fungi, pupils begin to explore the natural world around them, conceptualising by naming species and focusing on their characteristics.

The lesson

The learning process of fourth graders, as anticipated by Kristian, can be analytically construed to depend on the following steps:

1. Stimulate the pupils' embodied learning in the forest, including stimulating reflective processes related to past forest experiences.
2. Encourage pupils to become aware of their surroundings.

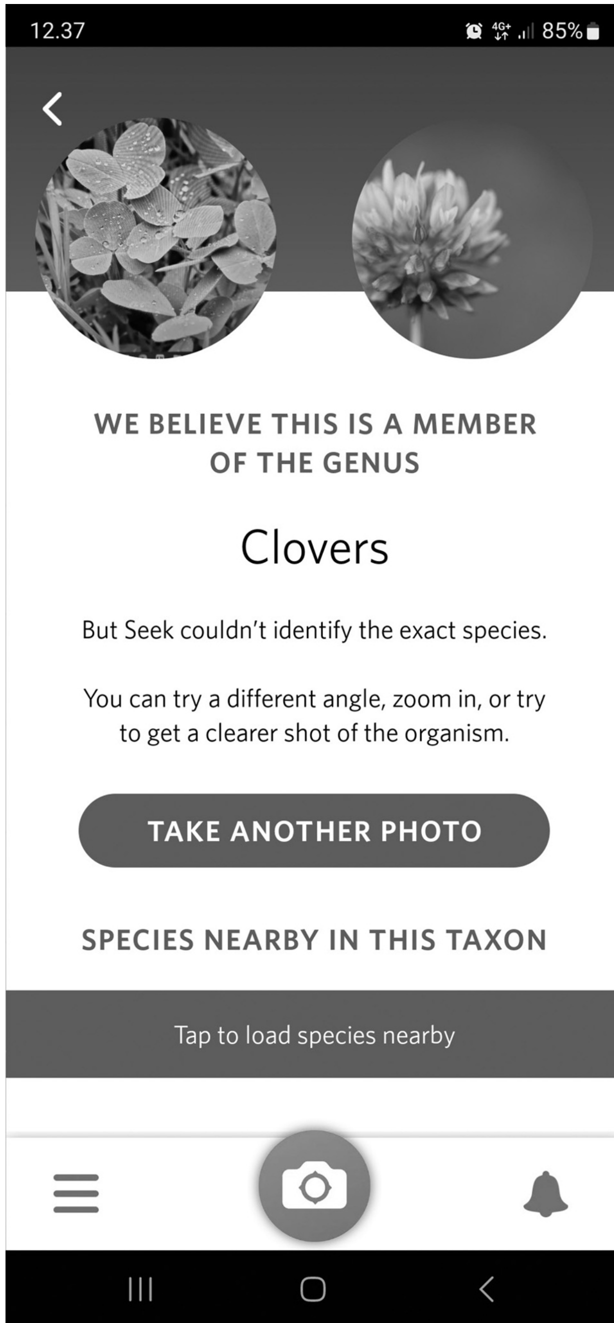

Figure 13.1 Screenshot from the Seek by iNaturalist app of a search on clovers.

3 Encourage pupils to evaluate, select, document, and store interesting findings.
4 Use an app to identify and conceptualise findings by naming and reading about them.
5 Recapitulate and reinforce learning with the class back at the nature school.
6 Tacit identity and meaning-making of who they are in relation to forests and nature.

In this situation, social elements are included as the pupils work together and may be inspired by their classmates' findings, and use them to guide their own search. Furthermore, the setting allows some pupils to make extraordinary discoveries and thus position themselves as particularly lucky or skilled observers. In what follows, we describe and analyse Kristian's class by drawing out specific invisible elements in each step of the pupils' learning processes.

Embodied learning processes

Here, we examine how established learning strategies—including identity-related facets of learning—manifest themselves during pupil-centred learning scenarios. Kristian's pedagogical intervention leverages the embodiment of learning. When the pupils arrive, they may experience various states of being hot, cold, fresh, tired, dissatisfied, or content. They will orient themselves and listen to the introductory remarks and supplementary instructions. They are instructed to explore the forest and search for curiosity-inspiring objects. Unlike many adult-led forest trips, their investigations are not confined to the paths. Consequently, while they are on the move, the pupils learn to interpret the forest floor, gaining experience with wet, slippery, and icy sinkings, among other things. Some may opt to stroll or jog through the forest hills, while others may engage in balancing or gripping onto tree branches. They explore the area actively, utilising their senses to hear, smell, and observe. Cold hands will learn to hold on to phones, as gloves and phones make a challenging combination. They utilise their previously acquired knowledge of forests, winter, and school excursions, along with their related code of conduct, to successfully navigate this task. This prepares them to ensure their personal safety and behave appropriately during lessons and reinforces their previously learned and enacted bodily practices. Overall, this experience serves to build upon their existing situated practices.

Notice surroundings

The task promotes engagement with the environment, encouraging curiosity and exploration of the specific forest setting. Pupils are encouraged to develop their observational skills and differentiate between "normal" and distinctive forest elements. In this ongoing and dynamic experience-building exercise, they need to remain alert to their surroundings and potential discoveries. When locating spruce or pine cones, they use their senses to determine qualities such

as icy, wet, or dry and whether the cones have been consumed by animals. Vigilant observers will notice different movements in the forest, either from classmates walking nearby or from birds in the treetops. Through this exercise, pupils learn that some individuals possess a more developed perception than others. They will acquire attentiveness skills and learn to be observant.

Evaluate and document findings

When pupils are requested to capture images and videos of the forest, they are required to search, locate, assess, and evaluate distinct elements within their chosen environment. In doing so, they establish connections with their surroundings and apply their pre-existing knowledge. Consequently, their cognitive abilities are expanded. Utilising their devices, they can preserve and retain memories by capturing images of fungi sprouting from trees, partially eaten cones, or a bird of prey's silhouette soaring in the sky. Furthermore, they can create videos, record sounds and movements, and take written or audio notes in real time. Later, they save their findings on their phone to present them to the class, narrate, and share their experiences.

Identifying and naming

In the identification process, pupils use the Seek app and gain first-hand experience of how it works and how to search for answers. Initially, when scanning an item, the app proposes categorisation and naming that pupils may not be familiar with. Subsequently, they assess the app's suggestions. The learners switch their attention between experiencing the forest, using the app, and gathering knowledge from their peers. In doing so, they develop their ability to acquire knowledge in real time.

In this task, focus can be upheld by providing clear guidance, as digital documentation available on phones is often more efficient and expedient than physical books. Additionally, supplementary information can be speedily accessed on-site via the internet. Consequently, they come to appreciate that every query they might raise regarding the forest can be addressed. For instance, they may wonder if the nearby hills contain Viking burial mounds or why the forest was named as it is. The implementation of this usage practice thus instils a foundational curiosity about nature.

Recapitulation with the class

When summarising with the class, pupils share their findings and exchange tips on successful discoveries and technology operation, and the most effective ways to document results. Enhanced by phone-based documentation, pupils' memories are reinforced when "reliving" nature. Memories are consolidated and linked to new ideas stimulated by the reflections prompted by the summarisation sessions. The teacher may utilise the photos, videos, and audio clips

as educational resources for producing homemade e-books or posters. The more pupils engage with their collected materials, the greater the chances of reactivating what has been learned. Collaborative work facilitates the externalisation of the learned content via conversations, thus supporting the development of verbal skills and shared experiences. These processes strengthen the sustainability of the learning and assist in implementing the acquired knowledge in a practical context.

Identity and meaning-making

Many pupils have previous experience undertaking outings and trips to forests, which relate to how they perceive themselves in a natural context. Additionally, those accustomed to such environments have learned to feel safe and have become attuned to the specific aspects of the surroundings requiring attention.

Furthermore, they can select (either intentionally or not) their approach to navigating nature-based learning structures. Being a lover of nature can play a crucial role in shaping one's sense of identity. However, for some, being a trickster or a rebel may also be a defining aspect of how they view themselves and are viewed by their peers. It is in these contested social positions that they begin their journey. Similarly, pupils have their own perceptions about which classmates possess knowledge about nature, who is best at climbing, etc. They also hold perceptions of themselves in this context. These form part of their ongoing development of identity, which is negotiated in all spheres of their lives.

During such excursions, pupils enhance their understanding of themselves and their abilities within a forest environment. This contributes to the development of their meaning-making processes by introducing new factors (Kalland et al., 2005; Skar et al., 2016), resulting in new ways of comprehending and forming interpretations of the world. Those who do not typically consider themselves outdoorsy may realise that their keen eyesight or tech-savvy abilities in other areas can be advantageous during this activity, enhancing their sense of competence and potentially leading to self-perpetuating effects in the future.

Implications for education

The chapter highlights the construction and development of complex relationships, such as children's connection to nature, in the presence of physical and social opportunities. While nature education usually occurs in the classroom (Schilhab, 2021), we argue that there are significantly more experiential and embodied learning opportunities when lessons are designed as situated and contextualised learning experiences. The less visible learning processes may seem unstructured, but as we have argued, nature provides a rich learning environment. Outdoor play is an essential aspect of childhood and fosters

children's affinity with nature (Skar et al., 2016). Children forge familiarity with their surroundings, which helps to promote feelings of competence and confidence (Carlone et al., 2015, p. 131; Kalland et al., 2005).

Since it cannot be assumed that today's children grow up with a diverse range of nature experiences, it is crucial to guarantee that all children receive hands-on nature experiences through the education system. This will enable them to establish strong relationships with their environment. Incorporating phone usage can aid active participation by allowing pupils to search for answers on the spot. Contrary to when teachers instruct on, for example, identifying elements in the forest, this type of experience enables pupils to become self-sufficient by conducting their own searches and verifying answers through technology. Additionally, mobile phones provide new methods for contact and navigation in nature.

By integrating insights from social learning theory with 4E, we emphasise the embodied and perceptual facets of this context and demonstrate how a diverse range of familiar learning strategies are utilised in the way Kristian designs the pedagogical environment.

We propose instructing children on active and purposeful information retrieval using their mobile phones. We acknowledge that forest expeditions and mobile phone use in outdoor learning environments may be novel for some educators and necessitate alternative pedagogical strategies and classroom administration procedures. It is also important to note that incorporating mobile phones into nature-based learning does not decrease the importance of education and didactics. Rather, it necessitates a different approach to facilitating learning, including the critical examination of the phone's role, purpose, and answers. We acknowledge that challenges may arise, but we believe that adequate preparation and experience can overcome them. For example, a teacher suggests designating certain pupils as app super-users to aid the teacher in case of app-related issues.

Used purposefully, phones have the capacity to introduce innovative ways of involving more children and young people in first-hand, embodied nature encounters.

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14 How nature-like artworks induce perceptual processes benefitting education in general and science education in particular

Theresa Schilhab

Introduction

In short, scientific reasoning hinges on observations, hypothesis testing, and theoretical expectations (Chalmers, 2013). This assumption applies to the sciences concerned with natural environments like biology, geology, and astronomy. Within these knowledge areas, observations entail perceptual processes that intertwine with and ignite hypothesis generation. Thus, part of the scientific activity involves an observer taking the time to attend to, engage with, and perceptually dwell on tangible phenomena. According to Sheets-Johnstone (2023), such a dwelling in which a continuous dialogue between perceptual processes and idea generation occurs was essential to Darwin's scientific activities.

Obviously, nature is abundant with phenomena that appear intuitively and perceptually engaging. However, given the emphasis on perceptual activity, one may wonder whether perceptually oriented activities like experiencing artworks could be effective in similar ways and promote the sharpening of perceptual acuity of importance to many school subjects. Clearly, art is not homogeneously defined. Art can be beautiful, realistic, abstract, and also awful and shocking. Therefore, this chapter explores to what extent experiencing artworks from the 1960s' minimalist and geometric abstract movement, known as Light and Space exhibited at the Danish art centre Copenhagen Contemporary in 2022, sparks perceptual engagements and motivation for exploration. Of importance, the Light and Space artists contributed in their time to a radical shift in art, leaving a focus on object and meaning in favour of an awareness of how art and space are experienced with the body (Adcock & Turrell, 1990). Hence, my focus is on artworks where the artist uses a kind of *nature-related* materiality to stimulate the spectator. I will clarify this criterion more thoroughly in a short while.

Motivation

When pupils are introduced to science, they also train perceptual acuity (McBride & Brewer, 2010). That occurs when pupils observe birds in the sky or count the number of species in the schoolyard (Schilhab, 2021). Natural

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environments, such as a stream with freshwater invertebrates and fish, can engage pupils in detailed observations and lead them to ponder their findings (Magntorn & Helldén, 2007). The materiality of the natural environment is intrinsically stimulating and engages children in basic sensory experiences of light and darkness, movements, sounds, and odours. Bosse et al. (2009) conjecture that spontaneous observations and budding inferences about perceived relations stimulate pupils to understand how to construct more formalised scientific hypotheses and critical reflections in later science education.

According to embodied cognition conceptions, we are poised towards the processing of the incessant flow of phenomena in our environment (Klomberg et al., 2022). The parallel processing of how one phenomenon is linked with another—the butterfly with the flower while the sun shines at a particular angle—forms the basis of situated conceptualisation episodes (Barsalou, 2009).

Following the Attention Restoration Theory (ART), nature consists of particular features that facilitate soft fascination by attracting our attention and engaging us bodily through sensory and perceptual activities (Kaplan, 1995). Hence, nature's ability to ignite spontaneous interest of importance to science didactics may be unique.

However, art in itself shares some of nature's characteristics. Merleau-Ponty addressed the relationship between experiencing nature and art from the aspect of the richness of an aesthetic experience (2003). According to Guareschi (2017),

> Merleau-Ponty's philosophy aesthetic experience is intended as both perceptual experience (aisthesis) and artistic experience. In a conception in which the sensible level is prominent, the analysis of perceptual experience represents the pivotal element of investigation. Perception is related to sense organs and leads to the consideration of bodily experience tout court. Bodily experience appears in its expressive role regarding both the shared world of culture and nature.
>
> (p. 224)

Furthermore, following Guareschi (2017), MerIeau-Ponty considers

> art as a form of investigation of the pre-categorical encounter with the world. Instead of considering painting as code that transposes natural perception into an artefact, Merleau-Ponty proposes seeing painting as a genuine understanding of our experience of the perceptual world.
>
> (p. 228)

Art is, as suggested earlier, often materially exciting, for example, due to novel installations of composite materials and unusual structures, designed to disturb habitual thinking and provoke new insights (e.g., Funch, 1997). Traditionally, artists aim to entice the perceiver by promoting experiences that

stimulate thoughts and reflections in innovative ways (e.g., Johnson, 2018). Such effects can also arise in what I refer to here as *nature-related* artwork. These can either depict or allude to natural phenomena like the Moon, shadows, black holes, gravity, etc., or employ natural materials like wood, stones, water, etc. According to Fingerhut and Prinz, art experiences often elicit interest (2018),

> Generally, interest [...] is related to the appraisal of novelty and complexity. Interest might therefore be a good candidate for taking on the cognitive challenge that is often part of our engagement with artworks we appreciate [...]. Moreover, besides being a plausible candidate regarding its phenomenology and cognitive dimensions, it also captures the right action tendencies: We linger around the artworks that spur our interest. Those artworks that repay active exploration—which could be seen as a component of prolonged interest—are those we most highly value.
> (p. 112)

Interest may be similarly close at heart to children's involvement in art. Studies of aesthetic activities in Danish preschool children exposed to paint and canvases suggested the wealth of explorative and experimental processes elicited in the participants (Blume, 2015). Here, particular attention was given to the self-initiated explorative and experiential practices. As suggested by Bosse et al. (2009), "[Y]oung children are naturally curious. The desire to question, hypothesise, explore and investigate is part of their very being" (p. 10).

In the spirit of MerIeau-Ponty, this chapter addresses the capacity of nature-related artworks to perceptually stimulate in ways attributed to natural environments. The purpose is to explore whether experiences of art could induce perceptual processes of value to education in general and science education in particular.

Empirical work and relation with the 4Es

The cases presented here derive from an evaluation of the exhibition of Light and Space at Copenhagen Contemporary (CC) from December 2021 to October 2022 by the author (Schilhab, 2022). The evaluation concerned CC's pedagogical initiatives directed at children's informal science education.

The first case, the Moon experience, involves auto-ethnographic observations using thick descriptions noted in the evening after two separate visits, first alone and in the following week, accompanied by an experienced geologist and science writer (Wall, 2006).

The second case, a lab activity about the phenomenon of shadows, is based on my field observations of guided activities for children offered by CC alongside the exhibition written on the day of the observations.

The cases differ with respect to which 4E aspects they prioritise and which methodology has been employed to collect data. The Moon case emphasises

the elevation of experiential and embodied awareness in the sense of being perceptually and sensorially engaged, as suggested by ART, intertwined with idea generation. The perceptual involvement may occur through sounds, movements, odours, uneven surfaces, palpation, and so on, putatively engaging the entire sensory palette. Idea generation occurs as associations and incentives for further exploration and sharing of thoughts. The lab case addresses perception and idea generation from the perspective of the extended mind. Here, the term refers to the perceptual processing of actual phenomena while sharing attention, verbal thoughts, and tangible activities (Kirsh, 2010; Schilhab, 2013, 2017, 2018).

Both cases were chosen to unfold the potential of actual artworks in stimulating science-like perception, embodied engagement, and idea generation. The aim is to highlight science-relevant activities when experiencing art. Therefore, I refrain from discussing art experiences as such.

CC's perspective on the Light and Space Movement

Piggybacking on the spirit of the artists' movement Light and Space, the aim of the art centre was to explore new paths in learning by providing new educational outreach formats through experimentation and labs for space, light, colour, physics, and mathematics for children. In connection with the exhibition, CC aims to support science experiences by engaging visitors in new works of art that explore light and space using the senses. In continuation, the lab affords exploration of the world through colour filters, the drawing of mirror images, the creation of personal artwork using LEGO blocks, etc.

Presentation of the exhibition

The former shipyard buildings which accommodate the Light and Space exhibition and the associated workshop are remarkably spacious. The location at a prestigious pier area in Copenhagen comes with plenty of sunlight floating through gigantic windows. The exhibition area is large, and the ceiling seems literally unreachable. Guests are met with plenty of room for dwelling with and exploring an artwork, although touching is not allowed. The walls are generally acting like anonymous surfaces, unless they are accommodating an artwork, adding a clinical sphere to the environment.

The exhibition hall is filled with various artworks stimulating the curiosity of the guests and silently inviting them to perceive and reflect. Some artworks allow for explorations of the space, the effects of light, or the characteristics of materials—e.g., playing with shadows, mirroring effects, and optic illusions—while insistently asking questions about our senses and perceptual stances. Other artworks are inspired by natural phenomena and the laws of nature, exposing how light diffracts in different media and showing interference patterns or what happens when our eyes adapt to complete darkness.

The lab forms the last part of the exhibition and consists of five stations containing activities that relate to the exhibition to inspire visitors to interact and reflect on their experiences with the artworks and themes. At one station, the visitor is invited to draw first squares and then crosses while the direct line of gaze is blocked, and only a mirror image of their hand while drawing is visible. Dollhouse-like cube forms with mirror-coated walls allow guests to explore the effects when items are surrounded by several mirrors. This station alludes to mirror artworks by, e.g., Olafur Eliasson and Jeppe Hein (see Figure 14.1), located at the end of the same hall. In another station, blue, red, and transparent blocks of LEGO are offered for visitors to build their own artworks and inspect the shadows of their constructs by placing them on a lit surface (see Figure 14.2). Visitors are guided by signs instructing them how to

Figure 14.1 Mirror installation created by Olafur Eliasson in connection with Light and Space. Photograph by Niels Halfdan Hansen.

Figure 14.2 Pieces of LEGO to stimulate building activity in visitors at the Light and Space exhibition. Photograph by Niels Halfdan Hansen.

interact with the stations, and a host supervising the room offers guidance and inspiration as needed.

The cases

The Moon case is based in an almost white room with very few distinctive features to soothe the eye, resulting in noticeable confusion about its actual extent. The installation is located on the last third of the route of the exhibition. Before entering the room, we leave our shoes outside. The floor is soft and vaguely responsive under the foot, like walking in a pine forest. The floor is also slightly vaulted, descending towards the sides. The surface of the walls, the ceiling, and the floor appear airtight, and the noise seems to be parked along with the shoes. The light intensity in the room is high, with multiple

hidden sources at floor level, though calm and soothing. Only the darker door-shaped field of the entrance which opens up to the hall, leading to other installations, breaks the sensation of omnipresent light.

Tentatively, we move around in an explorative mode towards the edges, as the room has no corners. When talking, we choose to whisper. Occasionally, other guests are briefly passing by without entering, although there is plenty of room for more visitors. Deliberately, I refrain from talking with my friend about my first visit.

One week later, we discuss the experience. I throw questions exploring his accompanying perceptual and embodied awareness. My friend responds that his experience was that of resting in a big void—much like in a haze—with his eyes blocked by endless whiteness. He recounts the similarities with his childhood experiences of holidays spent in dense fog on the western coast of Denmark.

I, on the other hand, had a sense of experiencing the face of the Moon. Immediately when entering the room, this flash of the Moon experience occurred. This was primarily based on the sensation of the gentle, all-encompassing light with no discernible features; the arched "horizon"; and the impression of endless space. Also, the search for anchoring posts with almost bare feet and here meeting the uneven velvety and warm "moon" surface added to the sensation of touching an otherworldly materiality.

The lab case is based on a recurrent workshop activity called Science Art Club, open for families and children aged 6–15 years. The workshop is led by an experienced artist and art educator—Janet—who, on the day of observation, is introducing the shadow theme. She stands at a table that includes her personally produced examples of how to explore shadows from different materials and with different tools, such as transparent coloured foils, torchlights, and a screen. The workshop guests are invited to create products with which to explore the relation between various materials and shadows, and how to manipulate shadows by rearranging the object that casts it.

Two children—a boy of 6–7 years and a girl of about 9–10 years—are seated at the edge of the big box with blue transparent LEGO bricks. They construct buildings accompanied by a grandmother and, later, their parents.

After a while, the girl approaches Janet together with her father, carrying her cube-like building—octahedron—meant to balance on a single point. Unassumingly, she asks if there is a place at the lighted table where she may place her work. Janet immediately offers a vacant spot and then asks the girl if they should illuminate her artwork with the flashlight to watch how it emits shadow effects. The girl follows the light path inside the transparent bricks with her eyes and is pleasantly surprised. Janet then guides the girl to also discover the effects of the material in the shadow that falls from the construct as Janet moves the flashlight around. The shadow is visibly patterned. Suddenly, the girl disregards the object itself, the construct she has meticulously created, and now inspects the shadow as a factor that she can manipulate when controlling the direction of the light beam. Janet offers her the flashlight, and the girl examines the shadows enthusiastically.

The relationship between the light, the direction of the light, and the object now appears as a larger whole than before when she intended to place it on the table to be lit from underneath. She explores and discovers that there are more elements and relationships to the object than are apparent at first glance or which one has become accustomed to noticing.

The girl's father also attends when the girl manipulates the light. He is similarly engaged with exploring the patterns visible in the shadow. Surely, the pair will later refer back to the episode when talking about the visit and remember the construct and the shadow as an experience they have in common.

Nature versus the human condition

In this section, I discuss the cases in light of the embodied and the extended mind. First, I zoom in on the specific quality of artwork-induced perception. Second, I discuss how the experienced artist and art educator can intensify perception and idea generation in a child by employing their skills on a shared object.

Embodied perception of the Moon case

Nature-related artworks have certain capacities to facilitate embodied engagement, as they play with sensory experiences and engage our attention so that we become poised bodies as we attempt to acquire meaning. But do artworks provoke interest in the same way as nature does?

In many of the installations, specific sensory experiences are enhanced at the expense of others. For example, the Moon experience pivots around the uninterrupted white vaulted sight, generating the sensation of emptiness. Here, "space" is almost fully reliant on the visual input and the incessant palpation with the feet. The room is void of phenomena that move and activity among items. Sounds as tokens of causality—and thus life—seem absent (Jonas, 1954).

The downplaying of some of our senses seems less likely to happen when we experience nature. Rather, the perceiver is at the mercy of the dynamics of the natural world (Chun et al., 2011). Thus, such perceptual experiences come with an air of connecting to the *real* world by pointing us outwards, suggesting the near sensation of the "ding an sich"—i.e., irrespective of interpretations and viewpoints (Blumenau, 2001). Conversely, in experiencing artworks, the designed experience manipulates the weight of the senses to induce interest. This suggests that the experience is not about the real world and thus points us inwards to focus on how the immediate moment feels "for us", the "ding für uns"—e.g., *our subjective sensations.* The difference echoes Merleau-Ponty's concept of double sensation—the body as a physical thing sensing other bodies (1945/2012). Although we are equally perceptually engaged in both situations, the emphasis on experiences in nature tends to be on what is out there; with experiences of art, the emphasis tends to be on what happens inside of us.

How does this affect the didactic use of experiences of nature-related artworks in science education? The use of nature experiences to stimulate perceptual processes and idea generation is about associating external phenomena and gaining insight into *nature's anatomy.*

In artwork experiences, on the other hand, we sense the presence of a human creator due to its felt intentionality and the manipulation of our interests. This leads to engaging with the perceptual activity itself and, ultimately, to insight into our inner anatomy and the human condition.

Whereas nature's anatomy is at the very heart of science and thus of interest to contemporary science education, is the insight into the human condition of similar relevance? Increasingly, science education concerned with global challenges like the biodiversity crisis and the effects of climate change has been associated with pupils' emotional engagement with the topic (Schilhab, 2021; Schilhab & Esbensen, 2024). It has been suggested that for pupils to grasp sustainability issues, they must understand their concrete dependence on nature. Hence, artwork which induces self-reflection about, for instance, species-specific perceptual processes and the human condition holds the potential to critically unveil the biological foundation of human existence significant to our understanding of nature as essential to life and thus worthy of protection (see also Fredriksen & Groth, 2022).

Embodied and extended mind in the lab experience

In the lab setting, Janet's skilled guidance of the participant's perceptual processes and embodied experience visibly augment the girl's insight. Janet's intervention is based on her didactic deliberations, which—as opposed to nature's capturing of our senses—operate top-down towards a specific goal. Janet uses her skilled perceptions and experiences as an artist and mediator of art to guide the girl to both manipulate and investigate shadows. Conceivably, the girl would probably not discover how torchlights produce patterned shadows when lighting up transparent LEGO blocks on her own. Also, mere dwelling in nature without intervention would only allow her to observe those shadows which nature would produce on its own in the moment. With the help of the torchlight, Janet's skills make her challenge the concept of shadows in multiple ways. Together with the girl, Janet unfolds aspects of the situation, which would be hidden in the bottom-up mode prevalent in nature.

It is worth noting that the use of nature to learn about nature's anatomy is just as much an example of extending pupils' cognition. Although a skilled science teacher may not manipulate nature in the way Janet manipulates the LEGO construction, they may use the materiality of nature to share experiences, verbal thoughts, and tangible activities (Schilhab, 2021).

Hence, the embodied and extended engagement with either nature or artwork coexists, and they affect much more than their perceptual acuity and generation of ideas. Direct experiences in both cases are always highly

embodied and sensorially meaningful and, therefore, intrinsically interesting, which thoroughly increases pupils' chances of remembering, sharing, and reflecting upon the event with learning effects that outlast school (Schilhab, 2017).

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Part VI

Music and physical education

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15 Embodied music learning

Alexander Refsum Jensenius

Introduction

There is excitement in the room when I enter the school's auditorium to attend my daughter's end-of-semester show. The parents take their seats, the light dims, and the young children march on stage and prepare to sing. The teacher starts a backing track, played overly loud through a pair of prominent speakers hanging high above the stage, and the children begin to sing. All goes well in the first verse and chorus, but the kids are so excited that many do not recognise the one-bar break before the second verse starts; the result is chaos. Some kids continue singing independently of the backing track, increasing their tempo. Those who waited for the extra bar get confused by the others, and many stop singing. The teacher stands in the front, gesticulating, trying to get the kids to sing together. The pre-recorded backing track plays on. Eventually, the teacher gives up and signals to stop the playback. The parents applaud encouragingly despite the chaotic performance. I see my daughter walk off the stage in despair. Afterwards, she says she will never sing with her class again. What went wrong? How could something as simple and natural as school class singing fail so miserably?

In this chapter, I discuss "embodied music learning" and explore how technologies can support new forms of musical exploration in classrooms. Ideally, technologies help "amplify musicality", an expression Brown (2014) uses to explain how the technologies of our time can enhance music-making, learning, and teaching. However, a problem with many current music technologies is that they are not "classroom ready", nor are the teachers adequately trained to use them effectively in classrooms. The result is poor learning and general techno-scepticism.

My entry point to embodied music learning is as a researcher on the crossroads between music cognition and music technology, and as a teacher in a generalist higher education music programme. I will start by introducing the "musicking" concept (Small, 1998) and merge it with recent theories of embodied music cognition (Clarke, 2005; Cox, 2016; Leman, 2008) and 4E approaches (Gutierrez, 2019; Schiavio & van der Schyff, 2018). Then, I give examples of how "musicking technologies" can be used in 4E-inspired teaching.

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Musicking

What does it entail to "learn music"? Is it to learn how to listen to music? To learn how to play an instrument? To learn how to build an instrument? To learn how to compose? To learn how to analyse? To learn how to appreciate music cultures? I like to think about all of these and use the inclusive verb "to music" to explain that music is not an object but an active process. When Small (1998) introduced the concept of "musicking", it broke with a tendency (in Western cultures) to objectify music. Throughout the 20th century, European musicology was primarily concerned with musical notation, and formal music training was focused on learning to play pre-composed scores on standardised instruments. Such a score-focused approach led to thinking about music as a "thing" rather than a process.

The objectification of music has not become less with the abundance of pre-recorded music surrounding us everywhere. One can easily live a life listening to music from morning to evening: from a home entertainment system in the living room, on the mobile phone while commuting, and on the radio at work. Even if you are not listening to music on your own device, there is often music in cafés, on the bus, in shops, and on both traditional and social media channels. Never has so much music been available, but most of this music is experienced passively, as background tracks to our lives. This may not necessarily be negative, but how does it affect our ability to make music ourselves? Moreover, how do new generations learn music in this—from an evolutionary perspective—new musical environment?

In the book *Ways of Listening*, Eric Clarke (2005) argues that listening is an embodied activity exploiting the multimodal capacities of our bodies. He builds on the ecological psychology of Gibson, who argued that "[o]ne sees the environment not just with the eyes but with the eyes in the head on the shoulders of a body that gets about" (Gibson, 1979, p. 222). Music is also experienced through such an "action-perception" loop. This is not only the case when dancing or jogging to music; people move to music even when they try to stand as still as possible (González Sánchez et al., 2018).

Figure 15.1 shows a model of "embodied music cognition" inspired by a more complex model developed by Marc Leman (2008). A performer can be seen as making music with an instrument. The interaction between the performer and their instrument is based on what I call "action-sound couplings" (Jensenius, 2022). The performer acts on the instrument, and the instrument re-acts with vibrations experienced in the performer's body and heard as sound through the ears. The action is based on an expectation of what will come, and the expectation is based on experienced actions. Similarly, the perceiver hears the sound from the instrument but can also see the interaction. I use the term "perceiver" instead of "listener" to stress that the experience of music is inherently multimodal. In the model, both the performer and perceiver interact with what Gibson (1979) called the "environment". The environment can be other people, a room, or something else external to the person in question.

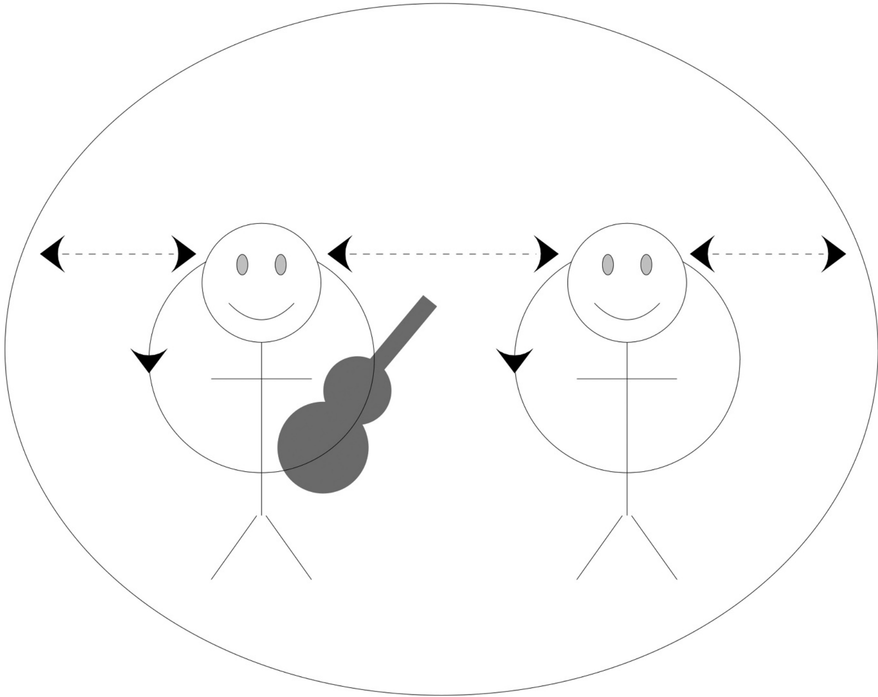

Figure 15.1 A simplified model of the internal action-perception loops of performers and perceivers, the performer's interaction with their instrument, the interaction between performer and perceiver, and their interaction with the environment. The model shows the complexity of a musicking situation.

The most important is a continuous action-perception loop, forming the basis for the enactment.

The musicking quadrant

Musicking is not limited to music performance or perception but includes various musical activities. Figure 15.2 shows a model of the "musicking quadrant", organised in a matrix-like structure related to time and function (Jensenius, 2022). Musical activities that happen "in time" include performing and perceiving music, while "out of time" activities include building instruments, composing pieces, producing records, and analysing music. This temporal distinction resembles the concepts of "online" and "offline" effects in embodied cognition theory, where offline is used to describe when action-related processes are temporally separated from relevant perceptual processing, thus contributing in a top-down fashion (Schütz-Bosbach & Prinz, 2007).

In the musicking quadrant, perceiving and analysing music can be seen as different ways of experiencing music, while the others are concerned with

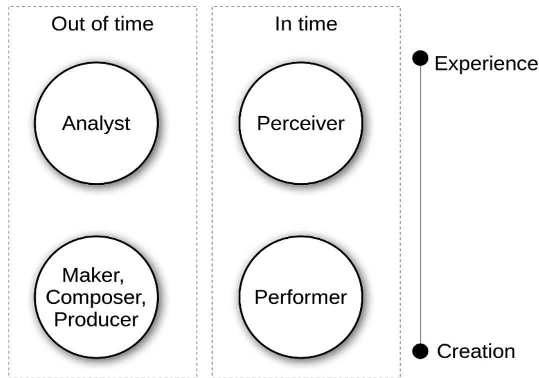

Figure 15.2 The "musicking quadrant", a model for investigating relationships between different types of musicking (Jensenius, 2022).

creating music. There are many overlaps between these roles. Composers may develop melodies, rhythms, and chord progressions while playing an instrument, and improvisers arguably compose "on the fly" during a performance. Still, the musicking quadrant helps explore what falls between categories, and it also helps explain why the Western music world is still primarily structured around these categories. Many higher education institutions have separate tracks for performers, composers, producers, and music theorists. Graduates have distinct career paths and are members of independent professional organisations.

New technologies challenge traditional conceptions of the roles in the musicking quadrant. Traditionally, instruments had to be built before they could be composed for and before someone could perform with them. Nowadays, instruments can be built during a performance, such as in the music genre called "live coding" (Blackwell et al., 2022): The performer creates sound on the fly while sitting on stage with a laptop and writing a computer programme projected on a screen for the audience to follow. The audience can watch the development of the instrument and composition (manifested on screen as code) while listening to the sonic output.

Other types of new music performance technologies also challenge traditional musicking roles. In what is often referred to as "new interfaces for musical expression" (NIME), the composition may be embedded into the instrument (Jensenius & Lyons, 2017). Then, composing may also include building the instrument, which blurs the boundary between the instrument maker and composer. Laptop musicians often perform with software that works in both real-time and non-real-time modes. The "composition" is usually not a traditional score but a collection of pre-loaded samples and presets in the software, blurring the lines between composer, producer, and performer.

Similar technologies and musical concepts are increasingly available to perceivers. New mobile phone apps allow for remixing tracks and adjusting musical parameters on the fly. Some artists release apps with multitrack versions of their songs that users can modify at will. This opens for more "active listening", in which the perceiver becomes a performer. It breaks with the century-long tradition of listening to pre-recorded tracks and engages the user actively with the musical material. New music technologies add enactment to musical experiences. Today, children have access to these technologies on their phones, tablets, and laptops at an early age. How does that impact music education in schools?

A failed performance

My daughter's school singing is an example of how music technology may both encourage and discourage musicking in an educational context. On the one hand, the choice of playback technology encouraged the children to sing, but on the other, it was also one of the reasons the performance failed. The problem was that neither the teacher—nor the children—had control over the pre-recorded song beyond starting and stopping the playback. This is an example of a non-interactive music technology that is difficult to use in a performance context where unexpected things may happen. Their performance was made inflexible thanks to technology without adjustment possibilities.

One could argue that engaging in musicking is positive regardless of the "quality" of the result and that there is also learning in failing on stage. However, it is counter-productive if it leads to children refusing to sing. I am sure the teacher had good intentions when choosing a professionally produced backing track to support the children's singing. However, if a backing track were to be used, choosing an interactive music technology that allows for a suitable control level would have been better. Many hardware and software solutions are available that allow for adjusting the tempo and pitch of the music being played, as well as jumping back and forth in tracks. Such tools are well known to DJs and laptop musicians but are less used in general music education. This is partly a technological problem; many tools are developed for experts, not learners and educators. There is also a knowledge gap. Many teachers are not educated to teach various types of music technology. Many higher education programmes still regard music technology as an "add-on" to other activities rather than an integrated part of musicking.

As a music technologist, I often stress that new music technologies do not need to exclude traditional technologies. We never had backing tracks when singing in class when I went to school; our music teacher played the piano and could easily adjust if something happened. Missing the start of a new verse is a classic challenge for accompanists. If it happens, one can easily skip a bar to catch up with the singers. For the teacher, choosing the right technology for the job is essential. The key is flexibility and the possibility to adjust while

performing. It does not matter whether the teacher uses a piano or a laptop as long as they know how to play them.

Very soon, there will be commercial systems with embedded musical artificial intelligence that could have saved my daughter's performance. Systems with built-in "machine listening" capabilities allow for adjusting the musical response similar to a human performer (Erdem et al., 2022). Such systems are actively explored among music technology researchers. As opposed to previous music technologies primarily targeted at experts, many new systems are developed for general interactive musicking. The machine integrates the roles of analyst and performer from the musicking quadrant, and it can even compose on the fly. It also allows humans and machines to engage in musical co-creation.

Even though I am optimistic about the future of musicking technologies, we should remember that it is perfectly fine for children to music without any technologies. Learning to sing without accompaniment is a valuable musical and social skill: It requires listening to others and adjusting one's singing accordingly. It may be more challenging to produce a well-sounding result by singing without a backing track (or a piano, for that matter), but it may still be worth it in the long run. Clapping while singing helps keep the beat, and walking or dancing even more. Many children's games are based on combinations of singing and various types of bodily behaviour. Then, there is no need for backing tracks to keep the rhythm and understand the song's structure.

An action-sound approach

How can embodied music learning principles and musicking technologies be used in classrooms? Over the years, I have developed an action-sound approach when teaching new bachelor's students about interactive music systems (Jensenius, 2013). This approach breaks with the traditional way of teaching music technology separately from other music disciplines. My approach aligns with the 4E cognition principles and should be possible to explore also in school education. In the following, I briefly describe how it can be implemented.

Embodied

Many of today's core educational technologies—including laptops, tablets, and phones—are "disembodied" in the sense that they force the user to focus their gaze and restrict their action potential. This often leads to sedentary laptop musicianship, pushing buttons with the fingers. I always start my classes with an embodied exercise. This could be asking students to make musical sounds with their mouths or tapping on the table. I try to use laptops as little as possible. Even though mobile phones have more limited processing capabilities than laptops, they allow for more physical interaction. I ask students to form small "mobile phone ensembles" that move in space and use various types of gestural control as an integrated part of their musicking.

Embedded

After getting the students moving, I ask them to move to a different location. Making a sound in a dry classroom differs from producing the same sound in a highly reverberant space. For example, corridors usually provide a long reverb time, completely changing how sounds are heard. This engages the students to listen to the space and make sounds that fit their environment. By moving through the space, they also understand how location impacts sound wave radiation. Facing a corner is completely different from standing in the centre of a room.

Enacted

Many students approach musicking from the perspective of traditional musicianship: singing or playing a pre-composed song. That is fine if the aim is a specific performance. However, there is much learning involved in daring to improvise freely. This requires the coordination of the interplay between performing sound-producing actions on an instrument and the re-action of the instrument on the body. Again, this requires balancing listening and performing. It may be daunting, so I often approach improvisation by setting a timer: improvise freely for one minute, then take a one-minute break, and then improvise freely for one minute again. The breaks are significant: They stop the flow and let the student start over in the next run.

Extended

Once students are comfortable with their own instrument—whether traditional acoustic or novel electro-acoustic—I ask them to improvise together. Musical improvisation is a form of group-based "problem solving". You need to be alert, attend to what others are doing, and contribute something yourself. It requires a constant interplay between mind and body, body and instrument, and an attuned focus on the group's output. Sometimes I ask students to use microphones and small amplifiers when performing together and produce the same sounds while changing microphones and speakers. They can also explore connecting microphones and speakers in various constellations so that they lose track of their "own" sound. This is an efficient way of learning microphone technique, but, more importantly, the students learn to appreciate the distinct qualities of various amplifying technologies.

From sound-making to music-making

I developed my action-sound pedagogy after several years of more conventional teaching. Instead of teaching digital signal processing from beginning to end, I focus on essential musicking skills: how to build an instrument, produce sound, listen to the sound, and play with others.

Even though novel instruments open new musical avenues, they are still what Libin (2018) calls a "[v]ehicle for exploring and expressing musical ideas

and feelings through sound". Laptops and mobile phones can be such vehicles, but so can a coffee cup and a pen when used as a percussive instrument. A rubber band can be attached to a chair and function as a string instrument, and a bottle can be turned into a wind instrument. The students learn that they can create sounds with any object in their vicinity. They just need to use their imagination when picking objects, position themselves in a suitable acoustic environment (or improve the acoustics through microphones and speakers), and listen to the sounds they produce.

There are several reasons why I avoid using traditional instruments in my teaching. One challenge is that most traditional instruments are hard to master. People practice the violin for years before it sounds "nice". Another challenge is how many traditional instruments are built around specific musical logics. Magnusson (2018) argues, "[i]nstruments are impregnated with knowledge expressed as music theory". Many of them, including the piano, favour musical genres based on the Western, tempered, 12-tone system. A recorder helps the user to play tones within the tempered tonal system. A guitar in a standard tuning makes playing songs in A major easier than F major, and a piano affords playing songs in C major on the white keys.

The piano is an example of an instrument in which the performer has relatively little control over the sound. One hits a key and gets a sound. I often say that the piano has two "degrees of freedom": the pitch (which is controlled by deciding on which key to hit) and the velocity (which determines how loud the sound will be). Thus, the piano is quite limited in its sonic capabilities and lends itself better to creating combinations of tones, such as playing chords in various combinations, than playing single melodies.

Several traditional acoustic instruments can be seen as music makers in addition to being sound makers. Organs have systems for playing intervals with one finger. Chord progressions are integrated into the instrument design in accordions. Many electro-acoustic instruments have continued this trend of embedding musical knowledge. Today's digital music systems can play sophisticated musical structures independently, and AI-based instruments can make music in any style and interact successfully with human musicians.

Unfortunately, many 20th-century music technologies are "disembodied": they have been developed based on the limitations of available technologies rather than the capabilities of human bodies. Many music technologies have an abundance of buttons and knobs encapsulated in square boxes with lots of cables (Jensenius & Voldsund, 2012); they have masculine designs and names (Jawad, 2020), and have not been particularly accessible (Frid, 2019). Fortunately, there has been an "embodied turn" also in music technology research over the last years (Lesaffre et al., 2017). Corintha and Cabral (2021) analyse how three digital musical instrument prototypes employ principles from 4E cognition. They highlight that developing one instrument that covers all dimensions is difficult. This aligns with my reasoning for not focusing on one particular instrument.

What I find most exciting is that many new interactive music systems continue to explore the blurring of roles in the musicking quadrant. Composers and performers build instruments themselves, instrument makers integrate

complete compositions in their designs, perceivers interact with pre-recorded musical elements, and analysts participate in performances. This also means that it is increasingly difficult to define an instrument or limit the capabilities of a media playback system. This is why I prefer to talk about *musicking technologies*, technologically based systems that allow for exploring music in various ways beyond traditional musical categories. They will not replace traditional music technologies but will complement them and, hopefully, allow for more active musicking in the future.

In sum, one of my ambitions is to develop new embodied musicking practices and related technologies, thereby opening more exploration between the different parts of the musicking quadrant. Traditionally, music performance has been considered the most embodied musical practice. Composition is often taught theoretically, using symbolic representations (musical scores). The analyst's role has also been theoretical, reducing musical experiences to words, numbers, or other symbolic representations. However, both composition and analysis rely on embodied knowledge, which can (and should) be emphasised in music education. The musicking quadrant can be a tool to help talk about different musical engagements and explore various types of musical—and bodily—engagement.

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16 Teaching and learning in physical education teacher education

Gunn Helene Engelsrud

Bodily resonances from the ground

I begin by presenting a situation that might not initially seem relevant to teaching and learning in physical education (PE). However, I use the situation to illustrate how bodily resonances exist and are created between the subject and the world. I do this because when, or if, bodily resonances go unnoticed in PE, it can have the consequence that pupils lose track of these experiences that ground human cognition. The following example offers a reminder that bodily experience from a first-person perspective is a primary position for being in, and thereby acting and moving in, the world:

> During the 2004 tsunami, the elephants noticed that the soil and substrate were different than usual, even before the wave reached the shore. They sensed the earth through their feet and saved themselves by moving away from the sea. People, conversely, were keen to see what kind of wave was approaching the shore. The elephants extracted their bodily responses from the world they sensed and "evaluated" the situation far better than the humans, who let their concern about seeing what was happening have an impact on their actions.

This example provides insight into the non-conceptual, yet ever so clear, understanding of the elephants' embodied connection to their surrounding environment. The elephants' actions showed how they perceived and responded to the vibrations in the earth through their feet and whole bodies. The elephants listening to and "asking" the earth if they were safe or in danger is, according to Fuchs and Koch (2014, p. 2), an example of what animals do when they, through their bodily experience, examine whether a tree is climbable or whether water is drinkable, for example. So, the question is: why were (some) people keen to see the wave, and why did they prioritise their visual senses over kinesthetic listening, which means to listen through the skin and feel the contact with the ground? In principle, human beings embody the same relationship with the earth as animals, but as mentioned by Berg Eriksen (2000), senses like vision and listening team up with intellect to create a

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response, while kinesthetic feeling and sensing team up with the body to do so. However, as Berg Eriksen points out, a hierarchy exists between the senses, where vision affects distance and judgement and invites the subject to obtain a third-person and objective point of view—while the more bodily senses such as touch, smell, and taste take a first-person, subjective, and intimate point of view that requires proximity. People also know from their own personal relationships that in social situations, before a word is even said, we experience each other through being spoken to or ignored. Unpacking experiences without words shows us exactly how experiencing kinaesthetic feelings takes place in shared spaces between people.

So, the question remains: why were people keen to see the wave? What kind of knowledge did people draw on to prioritise watching the wave and perceiving it as something exciting through their vision? The wave probably appeared to them as "important" or, in a strange way, "attractive" (Fuchs & Koch, 2014, p. 2), and this exciting sight overruled other bodily emotions and vibrations that could be felt through the feet and body. This brings us to the understanding of bodily resonances underlying micro-sensations: feelings of warmth or coldness, tickling or shivering, pain, tension or relaxation, constriction or expansion, sinking, tumbling, lifting, etc. They correspond, on the one hand, to autonomic nervous activity (e.g., raised heartbeat, accelerated breathing, sweating, trembling, visceral reactions) and to various muscular activations, bodily postures, movements, and related kinesthetic feelings (e.g., clenching one's fist or jaws, moving backwards or forwards, bending over or straightening oneself) on the other. Without these emotions or others as part of our experiential knowledge, the world lacks meaning, and as pointed to by Fuchs and Koch (2014, p. 4), when people are affected by affordances of a situation, it triggers a specific bodily resonance ("affection") which in turn influences the emotional perception and evaluation of the situation and implies a corresponding readiness to act.

In summary, it is this state that I refer to as the subjectivity and emotion in understanding teaching and learning in this chapter. Without including subjectivity and emotions, the teaching of PE and physical education teacher education (PETE) would run the risk of being mechanical or instrumental (Standal, 2015), where traditional learning of culturally mediated patterns of physical activity and sport are reproduced (Aasland & Engelsrud, 2023). The massive criticism of sport discourses in PE and PETE claims for an alternative pedagogy. In this chapter, I therefore try to unpack how a phenomenological understanding of teachers' and students' bodily and emotional sensing plays a crucial role in creating a socially inclusive space for learning that is not based on a distancing objective perspective and measurement of movements. Such a perspective is also supported by the research of Antonio Damasio (1994), who, from a neurobiological perspective, has shown how emotions play a central role in social cognition and decision-making. The elephants' emotional and bodily sensing, and the relationship with the earth that this gave them, helped them to "take the decision" to move in the right direction, away from

danger. Far from being barriers to making decisions and taking action, bodily emotions and sensations relate to the knowing body and can help us to make decisions in all sorts of situations. Relying on emotion in knowledge creation is also advocated for by Hanne De Jaegher and Kym Maclaren. By including Maclaren's concept of "letting the other be", I explicitly use the subjective perspective in teaching space as a theoretical grounding. The idea of "letting the other be" is an argument, first and foremost, for avoiding regarding, implicitly or explicitly, pupils as objects for the teachers' own learning aims, the curricula and educational policy, and regarding them as autonomous beings with their own goals and aims. It does not mean that learning outcomes are not relevant; however, to understand pupils as embodied beings-in-the-world with their own ways of approaching learning is—as I advocate for—the grounds for PE and PETE to count as an educational space for human beings.

Students are not objects of curricula and politics

Students are not objects of curricula and politics; they have their own goals and should be treated accordingly. Unfortunately, in the history of PE and PETE, bodies have and acquire different values (Aasland & Engelsrud, 2023; Aasland et al., 2017, 2020; Hill & Azzarito, 2012) in how they are included and added to gendered and status values. (There is extensive literature in this field that I do not go into further.) The teaching culture in PE requires a theoretical and critical discussion on the risk of objectifying pupils. If the teacher takes an objectifying perspective towards pupils, the pupils themselves might easily adopt that perspective of themselves, with a possible consequence being that they prioritise distance over emotional bodily sensing. It is important to be aware that the tradition in PETE is to construct the teacher as a professional working from the outside perspective, where *seeing* the pupils is given a prominent position. However, if the intention is to be aware of the needs of the pupils, sensitivity is needed to grasp their experiences. To understand the subject in its own right is, however, not yet formulated as a position for teaching in PE (Borgen & Engelsrud, 2020). Maclaren (2002) used the example of a horse trainer who knowingly helped "break down" a horse's own rhythm. The trainer, like a teacher, had his own goals for the horse's performance and was not able to achieve his own coaching practice and strategic goals until the horse broke down and could not take any more. Maclaren wrote that the trainer did not see the horse in its "horseness"; he saw the horse as a means for what he himself wanted to achieve, and in practice, he did not include the horse in a relationship that living beings share. Moreover, Maclaren wrote that although we as humans can keep our thoughts (in this case about the horse) to ourselves, we still must act in the world and thereby expose ourselves, exemplified here by the act of destroying the other despite any good intentions. The ideas that emerge from the culture and history around the body and PE must thus be considered and revised for humans to engage in ethical relationships, where sensory intake and bodily awareness play a significant role.

Physical education and PETE are also researched from a phenomenological perspective and include knowledge of the whole human bodily subject as being moved and moving, both by explicit intentions in education and teaching practices and by the pupils' and teachers' implicit histories, bodily resonances, and affective relationships. The direction in PETE that I consider the main point of an educational practice is to learn about humans as emotional bodily beings that live together with other people and circumstances in the world (Todes, 2001) and that students achieve embodied self-knowledge (Standal & Bratten, 2021). One argument for embodied self-knowledge in PE is concentrated upon:

> re-achieving a direct and primitive contact with the world and endowing that contact with philosophical status. It is in the search for a philosophy which shall be a "rigorous science", but it also offers an account of space, time, and the world as we "live" them.
>
> (Merleau-Ponty, 1962/2005, p. vi)

Inspired by Merleau-Ponty's approach, we can acknowledge that a person's own subjective bodily experiences can count as knowledge. A subjective perspective means that the living and lived body, from a first-person point of view, could not be observed from other perspectives: "It is our very manner or way of being in the world and, as such, it allows us to adopt perspectives in the world. Thus, we 'are' our bodies in a fundamental sense" (Heinämaa, 2021, p. 257). I take this as an argument to include bodily self-knowledge—which means discussing the role of experiential knowledge, subjective knowledge, embodied knowledge, and self-awareness—as a concept related to the understanding of PETE and PE.

Learning about ourselves in education

Basing teaching on contact with one's own and others' bodily states means that the ontological understanding of the body as *a being-in-the-world* comes to the forefront. Hanne De Jaegher (2019) claims that humans' obsession with what is important in life should be better elucidated in research. She highlights a dialogue that inspires, a memorable meal and the opportunity to find your way through an unfamiliar landscape—examples that involve relationships and create experiences that fluctuate in terms of the body, meaning, and companionship. Such experiences are not measurable; they are part of the existential condition of living as a bodily subject in a double dialectic as both the one who sees and the one who is seen, the one who touches and the one who is touched. In this situation, Merleau-Ponty (1960, p. 168) wrote, "My two hands 'coexist' or are 'co-present' because they are one single body's hands. The other person appears through an extension of that co-presence". Related to PETE, the moving subject is the self-moved mover that rests upon a positive appeal to the experienced unity of freedom in the spatio-temporal field and which, according to Todes (2001), is a field that is produced by the way the body's specific structure both

constrains and enables one's movement skills. Fuchs (2016, p. 195) claims that through bodily resonance, we notice and gain an intuitive understanding of the feelings of others and that this arises in our bodily engagement with them and the world (like the elephants noticing a new vibration in the soil). This is a perspective in which humans clearly notice each other. The body is mobilised when we are facing human experience, like how Fuchs and Koch (2014, p. 2) describe what animals do when they examine whether a tree is climbable or whether water is drinkable. Teachers and students experience each other by communicating and through emotions. For PE pupils, their emotions when they are "free to move" might be wild and full of energy: loud voices, playing with a ball, one pupil crying, and another telling a sad personal story. The examples illuminate that the experiences pupils have from being taught in PE are unpredictable and do not always follow formalised learning outcomes.

Teachers might find it difficult to approach such situations with sensitivity and clarity but could ask themselves: how could they provide space for these pupils and allow them to "be" in this situation?

"Letting the other be"

According to philosopher Kym Maclaren (2002), it can be challenging to accept "letting the other be", as they can lead to encouraging a "passivating" attitude towards others, or, in other words, allowing others to go their own way (as if they were isolated subjects).

However, "letting the other be" is *not* the same as not caring. It is about having the sensitivity to notice, receive, listen, and be in contact with the student as a self-moving mover. It indicates that the teacher can be with the students without saying, "Come on, come on, don't give up", which is often a standard phrase in PE. One alternative is that teachers embrace the situation and inspire pupils to perform in their own way and trust their own bodily resources and knowledge *to connect* in the very moment. There is no recipe for this: Teachers must be creative and revolt against traditional ideas of control and measurement of pupils' movements.

The other alternative is to encourage pupils to be concerned with their own thoughts and personal situation, and open the door for them to know themselves in what they learn. Maclaren (2002) writes that "letting the students be" is not something that happens as an intellectual achievement; it cannot be "conceived". Teachers must move beyond what they are accustomed to. Acknowledging and practising "letting the students be" gives rise to something new in the teacher's teaching. One example is to be bodily present and be together in the here and now, and letting language be bodily expressed, more than doing and talking in "old" concepts about assessing movements (Engelsrud et al., 2021). A language that includes the value of the micro-movement, signs between people that can be noticed subconsciously, gives accountability to bodily resonances as drivers for action and reflection, and as an ethical value for future development of PE as a school subject.

Emotions give direction and meaning: A relational attitude

Maclaren's idea of "letting the other be" also relates to "letting oneself be" and expresses a fundamental way of being-in-the-world, both subjectively and intersubjectively. It shows that in teaching situations, students are exposed to the teacher's view of them, and they are exposed to each other. "Letting the other be" also means feeling *oneself* as present and being "here" and feeling the "me-ness" of being here. When it comes to the bodily experience, "letting be" connects to body weight, volume, structure, senses, thoughts, and feelings of the body as they are from moment to moment, and experiencing the release of body weight towards the ground and registering what this does to our openness and presence in dialogue with others (Engelsrud & Rosberg, 2022).

Giving space to "letting the other be" becomes meaningful when teachers open the space for pupils to participate in each other's lives and intersubjectivity by way of their own subjectivity, as human beings understand themselves and others by engaging with and taking each other in through the body. Thus, before a word is said, humans know quite a bit about the mood of a room and the quality of the contact with others in it. The fact that humans can *notice* and *sense* others through the body is due to our bodies belonging to a common world (Zahavi, 2014). Maclaren (2002, p. 188) also writes that the person who lets others be is aware that, for many people, it means a struggle with one's own preconceptions of the other. Letting others be requires one to find their own free space within themselves and their relationship with others. It means being able to put habitual thinking about the other aside. When the other is perceived as annoying, this is not an objective feature of the other but something that occurs in the person experiencing the irritation, and others may have a different experience of the same person. Thus, an opinion about the other/a pupil cannot be generalised as unique traits of the person in question. By teaching others, the teacher can also help pupils learn about something they would rather be. Thus, bodily emotional learning occurs between and within human relationships, implying that there is the power to define the pupil as the other.

Embodied learning through being and experiencing

No movement can be learned without relation to being-in-the-world. Being means that sensory intake and processing of bodily resonance are driving forces for performing movements in relation to others (see Figure 16.1).

Something must be felt and sensed before it becomes a performed action, whether it is snow under skis, rain pelting on the body, another's nice smile, the squealing of tram tracks, heat in the head, or a loud whistle. Allowing time *to be* is an under-explored theme in teacher education in PE, as compared to being active and assessing movement skills. Hanne De Jaegher (2019, p. 1) comments on this tension: "Characterising knowing as a relationship of

Figure 16.1 Girl sensing and being. Photograph by the author.

letting be, provides a nuanced way to deal with the tensions between the knower's being and the being of the known, as they meet in the process of knowing-and-being-known." To include the idea of "letting the other be" gives teachers a perspective where they can explore and reflect upon what considering this phrase might provide in using the sensations from one's own body to help avoid objectifying the pupil, and by opening the spatio-temporal field for shared knowledge and dialogue, embodied learning can happen "by itself" with personal and intersubjective *rhythm* and harmony. Considering the non-conceptual bodily sensations that the elephants used to escape the tsunami, humans may practice listening to bodily resonances and be guided in the same way. The pupil in PE might, like the animal that wonders whether the tree is climbable, ask if the teacher is available for contact. Bodily resonances can give direction to the pupil if they should withdraw from or approach the teacher. These impressions are never static or defined forever, but initial indications that happen at a bodily level should count as an important knowledge base in PE teaching.

Educational implications

PE and PETE must be based on creativity and a pedagogy that favours sensitising oneself to the practice of "letting students be" in bodily learning. Students learn when the teachers take an interest in listening to them (with their whole body) and are receptive to what is happening in pupils' bodies in *the here and now* (Engen, 2021; Tyson, 2023). Planning and thinking about the lessons in advance should not take interest away from being "here and now". It is especially important for teachers in PETE to acknowledge students as bodily experiencing subjects and be aware of how they interact and shape – and are shaped by space. Students are bodily learners who should learn about themselves and be valued for who they are as pupils in a formative and educational context; to learn about themselves by noticing the qualities of their own bodies; their spontaneity, or lack thereof; and their perception of their freedom to move in their own way are important educational aims and values. Without a clear orientation towards humanity, the student may start to feel alienation towards themselves, others, and the teaching. By highlighting that human bodily emotion and sensation is a basic ground for knowledge in PETE, this chapter contributes to the questions raised in the discussions within the book. The concepts of bodily resonances and letting the other be lay the theoretical groundwork for using interactive processes as a basis for teaching in PETE. Taking such perspectives into teacher education is the opposite position of being a teacher who appears as a "besserwisser" (*know-all*) and teaching a pupil in ways that can break them down or alienate them from their own sensing, emotional, and knowing bodies. To avoid such an objectifying perspective, a teacher can create spaces for letting the students be who they are, as well as being together with the students. Meaningful and perceived experiences of being-in-the-world as embodied subjects must count as the source of educational and formative processes over time.

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17 Embodied learning in interaction

The case of aikido

Susanne Ravn

Introduction

In this chapter, I use a phenomenological and enactive approach to zoom in on embodied learning as it takes place in couple-based activities—for example, couple dancing and martial arts practices. These activities are characterised by there being a partner who, with different kinds of intentions, acts back on the practitioner's movement. For example, in Argentine tango, the dancers will strive to interact, so they move together as if "one creature of four legs" (Ravn, 2019), while in martial arts practices, the interaction is characterised by an antagonistic engagement: practitioners interact under pre-agreed rules to achieve control of their training partner (e.g., Ravn, 2022a). In such couple-based activities, embodied learning takes shape and becomes defined on interactive premises. The activities offer a unique window for investigating, describing, and understanding intersubjective dimensions of embodied learning in situations where the actual practices change via interaction with others.[1]

Throughout the chapter, I draw on the case of practising the martial art of aikido to both exemplify and drive the argumentation. The aikido practices described are based on an auto-ethnographic work which has been presented in full in Ravn (2022a). I firstly indicate how we are to be aware that interactions take place on multiple levels simultaneously and are culturally and socially embedded. I introduce aikido and its codes of conduct to exemplify this point. Secondly, I present phenomenological descriptions of embodiment and the incorporation of skills. These two first sections lay the ground for using extended and enactive approaches to describe how embodied learning is shaped *through* interaction, and how the continuous development of skills is nursed by the participant's ability to move beyond controlled engagement to give into the dynamics of the interaction. Finally, I emphasise how the case of aikido calls attention to aspects of embodied learning that will be of relevance to physical education.

Interactions are culturally and socially embedded

Analysing couple-based movement activities, one could easily come to selectively focus on the pair engaged in the interaction and to partly ignore the

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interactive aspects continually constraining and shaping the interaction. However, if we aim to understand how embodied learning is shaped through actions with other participants, we must first acknowledge that the interactive demands that it takes *to participate* in a practice and *to deliberately engage* in practising with a partner shape the actual interaction. That is, to participate, one will have to adapt to the explicit and implicit technique of the activity and to some degree also assimilate the social and cultural "rules" that characterise the activity. Interaction is, in this sense, culturally and socially embedded. In the case of aikido, skills are clearly defined according to specified techniques, but at the same time, it is quite clear that one cannot practise these techniques with a partner without also incorporating the specific codes of conduct characterising the apprenticeship learning traditions of the aikido dojo. Visible to anyone entering a dojo for the first time, practitioners are expected to wear a white *gi* (blouse and trousers), and if higher graded also a *hakama* (traditional Japanese trousers, often black), and to bow respectfully to one's partner. In the following the codes of conduct, ideals, and implicit rules of this martial art practice are specified, along with the ways in which they shape the interactive engagement of the practitioners.

Aikido is a Japanese-based martial art in which the one practising an aikido technique (*tori*) aims at being in control of an attacker and does so by merging with the energy of the attacking partner (*uke*) (Kohn, 2003; Palmer, 2002) (see Figure 17.1). Compared to other martial arts forms, *tori* does *not* aim at blocking or hitting back to achieve control but to meet and blend to redirect

Figure 17.1 Victor Merea, Sensei in our Odense Dojo, Denmark, performing a high throw. Photograph by Stefan Dall.

uke's movement (Ravn, 2022a). As a martial art practice, aikido is unique in the sense that the ideal is to win the fight without harming the attacker (Kohn, 2003). It is practised according to the apprenticeship learning of Japanese culture, meaning that each dojo will have a sensei—a master—who specifies the details of how each technique is to be carried out. At the same time, sensei refers to and learns from still higher graded senseis.

Codes of conduct include bowing rituals when entering the dojo and during practising appropriate ways of addressing questions to sensei and higher graded practitioners, and the way one carries one's body around in the dojo. Aikido skills cannot be deliberately developed without also assimilating these codes of conduct. Practitioners' incorporation of these aikido ways of behaving shapes their engagement in their here-and-now interaction with a partner. The specific aikido techniques and codes of conduct thereby productively constrain and enable ways to move and act. As an embedded aspect of learning, they present *supporting* or *scaffolding* structures for practitioners' to move and engage with their partners.

Embodiment and incorporation of skills

Phenomenology has provided valuable descriptions of how our experiential life is fundamentally grounded in an unthematic, pre-reflective body awareness constituting the world as there for us. As emphasised by Dan Zahavi following Husserl,

> [T]he body is not first given for us and subsequently used to investigate the world. On the contrary, the world is given to us as bodily investigated, and the body is revealed to us in this exploration of the world.
> (Hua 5/128, 15/287, cited in Zahavi, 2003, p. 105)

Embodiment addresses this fundamental characteristic of human existence and how any feeling of being is, of its essence, a bodily feeling (Merleau-Ponty, 1962/1998). It also follows from these phenomenological descriptions that embodiment is an ongoing process affected by, among others, ageing processes, cultural and social conditions, and deliberate engagements in training regimes and in learning new skills. Drew Leder (1990) has nicely indicated how the incorporation of a skill denotes the process in which a specific way of moving is grasped and comes to pervade one's being in an embodied sense. When the skill has been incorporated, it adds to, moderates, and reshapes the practitioner's potential engagement in the environment and with others. As Leder (1990) exemplifies, after one has learned the skill of swimming, the pool looks appealing and invites action in a different way. Phenomenologically described, the incorporated skill moderates one's embodied being. It adds to the embodied register of ways in which *perception-action possibilities* open for the practitioner and changes the practitioner's experience of "I can" (Merleau-Ponty, 1962/1998).

I now return to aikido to describe how the phenomenological account of embodiment and incorporation of skills are of use in the analysis of specific kinds of movement practice. I started practising aikido more than 20 years ago and remember quite clearly how the first years of training were focused on getting the basic movement patterns of the techniques into the body. I was deeply focused on coordinating legs and arms the right way. In these years, my partner was primarily there for me so that I could focus on practising the pattern and logic of a given technique. Later, I was able to be aware of my centre and my breathing while performing the techniques. I also became more and more aware of the timing that would give me control over *uke*'s movement. Along with developing nuances in how I perceived and performed a technique, *uke*'s way of moving became the full focus of my attention. The embodied learning became still more focused on the actual interaction, and I became still more aware of how nuances of interaction changed with partners with their different skills, sizes, strengths, and energy. Any new partner potentially invited—and still invites—new explorations of how a specific technique can be fine-tuned. My aikido skills are incorporated and form a background for focusing on the interaction, but they are also constantly in process and developing.

After a couple of years, being accustomed to wearing the *gi* and the *hakama*, I recognised that the specific aikido training outfit had facilitated my posture and way of moving on the mat. I had developed a certain aikido feel of my body. This feel of my body includes a certain sense of the aikido outfit (belt, material, and length), but is also reflected in visible physical changes. The physical training and the aikido codes of conduct had interweaved with my way of being and carrying my body when training and developing my aikido skills. In other words, the processes of enculturation and socialisation characterising the embedded aspect of practising aikido, not only address a structural relation to the environment but also affect the embodiment processes going on. They shape the embodied way I approach the training of a technique with a partner and develop my skills (see Figure 17.2).

As indicated, skills are much more than a motor-performance capacity the practitioner activates. Acquired skills are flexible, in process, and *enacted anew* on the condition of the actual situation. Skills are thus context sensitive and performed in open-ended ways (e.g., Breivik, 2016; Ravn, 2022b). For the beginner, aikido techniques might appear as separate and distinct skills to be learned, introduced as if part of a distinct repertoire of "I can". But after the first beginner confusion has faded, one begins both recognising and feeling how each technique is interweaved with the practice, contributing to the learning and exploration of other techniques. One comes to understand the skills as progressive results of a process in which aspects of the practice are distilled.

Embodied learning—Extended and enactive aspects

Extended and enactive aspects of embodied learning are closely connected and, in a more radical way, indicate how movement not only contributes to

Figure 17.2 I am training with a partner and showing the first phase of meeting *uke*'s attack to perform the specific aikido technique *shihonage omote*. Photograph by Victor Merea.

but is also part of cognitive processes supporting learning. While the embedded aspect touches on a *structural* relation to the environment that offloads the demands on the practitioner, the extended aspect addresses a *dynamic coupling* that potentially transforms the ways practitioners think and act. The enactive aspect specifically invites focus on how we perceive things in relation to what we can do with them. It also invites connection to and engagement with enactive theory—or enactivism, which is a biologically informed philosophy arguing that cognition is a fully embodied matter. That is, from an enactive point of view, basic cognition *is* an organism's response or coupling to an environment (Gallagher, 2023). To indicate how the extended and enactive aspects (along with enactive theory) might help us understand the embodied learning taking place in interaction, I return to the case of aikido to describe a noteworthy instance of interaction—and learning.

After having trained aikido for more than ten years, I visited and trained for two weeks at the main dojo of aikido in Tokyo—the *Hombu Dojo*. At one training session, I was invited by a relatively old and very experienced aikido practitioner, Taka-sensei, to practise with him. I had been told that he had trained daily at the *Hombu Dojo* for more than 40 years. According to the codes of conduct and the apprenticeship hierarchy of aikido, to be invited to practise by Taka-sensei indicated an appreciation of my competences and approach to training aikido and was to be considered an honour. No doubt, this knowledge raised my awareness towards my partner and the ways he would meet and lead me in the interaction. When we started practising,

> I immediately felt he was in control of the intensity of the interaction and any of my movements. He was over me with the technique nearly before I had raised my arm for the next attack. His movements seemed minimal—small steps without stillness—while I sensed that he had full control of my centre and that he could throw me any time he would like to.
> (Ravn, 2022a, p. 117)

In that moment, I was fully concentrated on the interaction and invested in merging with Taka-sensei's movement. I could not help first seeing his movement as relatively stiff and strangely imprecise compared to the precision, diagonals, and circles which I had aimed for, for years, when practising. However, when engaging in the interaction, his movements felt strong, connected to his centre, and extremely effective. He knew exactly where my balance was while he manipulated my movements and took control of my body. Taka-sensei was not only ahead of my movement but seemed to be directing and fine-tuning the directions—or the *intentionality*—of my actions. He was both merging with the energy of my movement and ahead of the intentionality of my attacks. Surprisingly, the same kind of experience was at stake when we changed roles, and he was to act as my *uke*, and I was to train in taking control of his movement:

> I immediately sensed a thick resistance in his movement and realised that I had to really push (too much according to the aikido ideals) to make him move and that the tension in my corpus rose. He moved but he also let me know in the way he followed my technique that I was not the one in full control. There was nothing else to do but to try to find a way to let the tension dissolve, experiment with my sense of centre, to let the circles of the technique begin from my hip movement while relaxing my arm movements. The more I found a way to relax and breathe the better he moved with me. The more I let go of insisting on directions and accuracy and attuned to the energy of his movement the easier I felt it was to move his centre.
> (Ravn, 2022a, pp. 117–118)

As shown in these extracts from my field notes, the potential learning at stake in this situation depended on me giving in to the interaction with Taka-sensei. In this learning process, I moved beyond being in a controlled engagement to the point of not knowing exactly what was to happen in the interaction.

Hanne De Jaegher and Ezequiel Di Paolo (2007) and Thomas Fuchs and De Jaegher (2009) have provided in-depth enactive and phenomenological descriptions which can help us understand what is at stake in interaction processes. From a pedagogical point of view, we might focus on individuals and their learning processes, but from the enactive perspective, the meaningful connection between perception and movement cannot be described as if (only) an individual affair. Rather, in fundamental ways, the meaningful connections between perception and actions extend to include the movement of others.

As a first step in their enactive analysis, De Jaegher and Di Paolo (2007, p. 490) define *coordination as the non-accidental correlation between behaviours of two or more systems that are in some kind or degree of coupling*. Subsequently, they distinguish between *coordination to* an object—typically a tool—and *coordination with* another subject. *Coordination to* addresses, for example, the extended characteristics of how the runner relates to and senses the terrain through the running shoe and how the tennis player senses and hits the ball through the racket. *Coordination with* addresses the way the meaningful connection between perception-action involves another agent—for example, a tennis competitor or another aikido practitioner. While the coupling to objects—like running shoes and tennis rackets—can be considered relatively static, the coupling between two interactors will be in flux. Both the tennis racket the tennis racket and the tennis competitor present extended aspects of the tennis player's embodied practice. However, the two kinds of couplings have different dynamics. De Jaegher and her collaborators' central point is that one's ability to *coordinate with* others is fundamental to social processes and that it works on a pre-reflective level of *intentionality* (De Jaegher, 2008; De Jaegher & Di Paolo, 2007; Fuchs & De Jaegher, 2009). In other words, the way one is aware of and directed at something and the way one's movement is directed and accentuated are shaped by the interaction one is part of in ways that work beyond conscious awareness.

Fuchs and De Jaegher (2009) continue to contribute a more detailed description of how, in *coordination with*, the process of interaction is driven forward in a continuous fluctuation between being synchronised, de-synchronised, and in-between states. In moments of synchronisation, the dynamic of the interaction becomes the source of the participants' intentionality—or direction—of their movements (Fuchs & De Jaegher, 2009). In moments of synchronisation, the very dynamic of the interaction shapes the way practitioners move, and practitioners involved will typically experience that everything "just seems to work". As a tango dancer explained, in such moments, it feels as if the dance dances him, and, at the same time, as he added, he realises it is still him dancing this dance (Ravn, 2019).

Let me return to the training session with Taka-sensei and remind the reader that when performing the aikido technique, *tori* strives to harmonise to be slightly ahead of *uke*'s movement, and *uke* strives to both be with and give in to the interaction so that *tori* can take charge. To do so, while training with Taka-sensei, I had to be skilful enough to enact the basics of the techniques "by reflex", so to say. This formed a ground for me being able to merge with his movement, to give in to the interaction while Taka-sensei harmonised to be ahead of my movement—ahead of my intentionality and thereby the way my movement finds direction. The way we enacted the techniques together took shape on condition of the dynamic of the interaction, exemplifying *coordination with* and incidents of synchronisation in the practice of aikido. The movement patterns of our moving bodies were both influenced on and by the life of the interaction in the here and now. Taka-sensei was ahead of my movement in a way that included pre-reflective levels of my intentionality, and he was on top of the dynamic of our interaction, both when taking the role as *tori* and *uke*; I moved beyond controlled engagement to thereby learn by being led through the dynamic of the interaction with Taka-sensei.

Implications for physical education

I have used the case of aikido to indicate the ways in which embodied learning in movement practices involves embedded, embodied, enacted, and extended aspects. While each section of the chapter has focused on a specific aspect of these four Es, it has been central to also indicate how these conceptual specifications present distinctions that overlap in the actual analysis of embodied learning in a specific movement practice.

It might be trivial to emphasise the social and cultural embeddedness of any learning process. However, I find it is important to recognise that the embedded aspect is intrinsically relevant to understanding how embodied changes take place. In other words, the social and cultural embeddedness should *not* be reduced to secondary layers or conditions of the activities taking place. I have thereby presented an embedded and embodied approach that resonates with current research on *collaborative aspects of embodied learning*, emphasising that the ongoing process of incorporating field-specific skills is, in a fundamental sense, to be considered an intersubjective affair (e.g., Bicknell & Sutton, 2022; Breivik, 2016; Ravn, 2022b).

In pedagogically oriented analyses of physical education, the term "embodiment" tends to be used to emphasise a heightened awareness of and sensitivity to processes of the student's own body moving (Ravn, 2022b). With good reasons, analyses aim at nuancing and developing the way embodied learning in physical education can be approached and described *beyond* the performance-oriented paradigm of sports activities (e.g., Aartun et al., 2020). However, using the concept of embodiment to emphasise the value of selectively focusing on the individual student's experience downplays the embedded, extended, and enactive aspects of embodied learning. The 4E approach to embodied

learning, as presented in this chapter, takes intersubjective and environmental dimensions of human existence as fundamental to the embodiment processes going on: any deliberate development of "I can" is a world-involving process. Not all activities involve partner work, but all activities do involve some kinds of environmental structures and interactive collaboration. These will affect and shape the embodied learning taking place.

Partner-based activities can specifically highlight how intersubjective aspects of activities are both visible and grounded in the dynamical coordination taking place and how the dynamic of interaction cannot be fully accounted for by describing patterns of actions versus reactions. Rather, we should pay attention to the interaction of activities as also having a life of its own and that the dynamic of this "life" potentially shapes *and* transforms students' movements and their embodied experience of these movements. To deliberately engage in this aspect of interaction, the participants must move beyond controlled engagement—potentially to the point of not knowing (Gallagher, 2023). Or, to put it another way, they must find ways to engage in the process of being danced by the dance, moved by the aikido partner, or played by the game. I hope the analysis and arguments presented in this chapter encourage teachers in physical education to engage in developing pedagogical approaches that invite students to become aware of how they can give in to interaction with a partner—to be moved through the dynamic—as such phases can be of high importance to develop skills and competences. Embodied learning in partner-based activities develops not only because of but *through* the other.

Note

1 The phenomenological and enactive approach presented in this chapter is closely aligned with a strong approach to embodied cognition (Strong EC) (Ruchinska & Ravn, in press). A Strong EC approach proposes that cognition is rooted in motoric processes and that movement and body-environment coupling are active parts of cognitive processing. In contrast, using a Weak EC approach, cognitive processing is understood as essentially internal and representational. In Weak EC, the body might inform cognition, but it is not considered part of the process of thinking (Gallagher, 2023).

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Part VII

Conclusions

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18 Conclusions

Camilla Groth and Theresa Schilhab

Having explored the authors' 4E(+) perspectives on learning through examples from the classroom and beyond, we can now reflect on what this means for teachers and teacher students more concretely. What are the implications for theory and practice that emerge? At first, this might be somewhat diffuse, as there are no straightforward action plans drawn out, no tables or clear instructions to paste on the classroom wall. Instead, the learning possible through this book still needs to be processed by you, the reader.

When you think about your own practice—how you prepare the students and the learning materials for your subject(s)—do you already involve aspects of the students' embodied learning experiences? Do your students have a possibility to engage with learning materials in a multimodal way; are they able to connect to the context of the subject matter; are they able to approach matters through active engagements and interactions? Now consider, are there ways in your practice that could improve the situatedness (Brown et al., 1989) of the students and consider their embodied participation more concretely—for example, through exercises that involve whole-body participation or through tangible means for scaffolding learning, such as using material extensions and building blocks?

In this book, we have shown how language learning, reading, and writing are abilities grounded in active and situated participation in and through the social and material world. The very notion of language is body-based (Chapter 2, Kokkola), and words and concepts may be traced back to human-environment interactions and spatio-temporal experiences such as "moving forward" as a way of expressing futures or being "down" as a way of expressing sadness. Words and concepts are our direct channels for meaning-making and communication, and thus also our ways of expressing emotions, to the point that words are even felt in our bodies (Lakoff & Johnson, 1980; Chapter 2, Kokkola). Such metaphors reveal that abstract ideas are deeply grounded in our experiences of the world through the senses.

Through language, we also embody cultures and ways of thinking about ourselves and others. Therefore, acknowledging the embodied nature of language learning is important both in native language education and in learning

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a new language. Studies of how languages emerged and how children learn languages emphasise the role of the whole body in meaning-making through language; separating words and grammatical forms from their embedded, enacted contexts lowers children's chances of making sense of them (Chapter 2, Kokkola). As even abstract language is grounded in the body, using gestures that draw on these connections helps children learn more efficiently.

Language learning does not just mean learning a new language or the command of grammar and vocabulary but also includes the process of developing, elaborating, and refining language as a personal means of expression (Chapter 4, von Bonsdorff & Marjomäki). Speaking a language is a way of being in the world, and bodily gestures play a fundamental role in this. When pupils experience difficulty in language acquisition or speaking, this experience may be daunting and affect the pupil's identity in a negative way. Holistic and engaging forms of education are important to boost children struggling with their language production, helping them find alternative ways of expression. Aesthetically supported, playful, and expressive modes of education may prompt spontaneous and self-motivated agency in pupils. Letting them perform as experts and narrators utilising gestures and images may help strengthen their linguistic competencies and self-esteem (Chapter 4, von Bonsdorff & Marjomäki).

Contrary to what is commonly thought, reading is not the mere internalisation and processing of text that we might have come to think of it as. In this book, we have shown that reading is a highly embodied, multisensory, material, and situated interaction between the reader and the sociocultural and material content of the read text that draws on previously experienced bodily interactions in our own lives and extends beyond into the imaginary (Chapter 5, Bro Trasmundi & Mangen). The materiality of reading and forms of writing also has consequences for how the learner experiences and remembers the content (Chapter 6, Korte & Körkkö). Reading is always intimately connected with, and shaped by, the technologies we use when we read (Chapter 5, Bro Trasmundi & Mangen).

The physical and psychological conditions of the reading environment are equally important for the possibility of engaging in deep and concentrated long-form reading experiences. For this to be realised in a school environment, it is necessary for teachers to consider both the embodiment and embeddedness of the reading situation—including the environmental framework, social interaction in the class, the teacher's behaviour, and, ideally, the individual pupil's reader identity and reader history (Chapter 7, Hauer). A calm, comfortable, and clearly defined reading environment, with a supportive teacher, offers pupils the best possibilities to concentrate and absorb themselves in the text and creates the best conditions for focused deep reading, as well as a pleasant reading experience (Chapter 7, Hauer).

This means becoming aware of possibly "hidden" or unidentified aspects in the classroom environment that either hinder or facilitate the reading experience. Often, the expectation of reading is laden with many restrictive

conventions, such as that reading should only happen in complete silence and without moving one's body or interacting with the content through reading aloud or by fiddling with the material aspects of the reading substrate (Chapter 8, Toro & Bro Trasmundi). When students are asked to read aloud, teachers might emphasise the importance of speed, flow, and accuracy over other aspects, such as interpretation or imagination. For students, this can be counteractive, and if the teachers show through their unappreciative bodily communication and (even unconscious) microaggressions that the student's behaviour is wrong, it might further lead to deterring students from wanting to read, even in their free time (Chapter 8, Toro & Bro Trasmundi). An embodied model of reading that allows open-ended processes of bodily engagement—such as creativity, imagination, and critical thinking—along with breaks, sounds, and movements might relax attitudes towards reading, hopefully thus engaging more young readers.

There are ways to engage with literature that considers the embodied aspects (Wilson, 2002)—for example, reading aloud is particularly well-suited to introduce preschoolers to the syntactic and semantic dimensions of language, the tactile materiality of books, and the imaginary worlds of narratives (Chapter 3, Schilhab et al.). The embodied cognition approach indicates that competent language use in conversations and reading emerges from first-person experiences with previously lived situations. Thus, when children learn to read, their experiences when reading or listening to reading become important both as part of the physicality of the reading experience and as part of attributing meaning to the text.

By arranging reading-aloud sessions as multisensory and social events that invite children to voluntarily participate, the early childhood teacher may lay the ground for positive experiences and a continued interest in engaging with reading activities. Additionally, such shared reading experiences have significant importance for the development of reading comprehension and vocabulary as books present a wider vocabulary than experienced in ordinary conversations (Chapter 3, Schilhab et al.). Of particular importance, reading aloud helps children train those imagination processes so important to reading comprehension and convergent and divergent thinking processes.

As the materiality and new affordances of reading and writing are profoundly changed by digitalisation, it is important to acknowledge the effects this has on the embodied experience of engaging with literature and expressing oneself through written media. As the change in material affordances also changes the interaction with text, it is important to be aware and make informed choices when choosing reading and writing media—it should not always be assumed that digital tools are qualitatively better or more efficient (Chapter 6, Korte & Körkkö).

Optimally preparing coming generations for various technologies and their affordances requires an improved understanding of how to enable and constrain reading and writing practices towards different outcomes (Chapter 5, Trasmundi & Bro Mangen). At the same time, it is equally important to continue

teaching learners to write by hand so they can develop various motoric and visuospatial skills. While writing by hand is seen to elicit a more embodied approach to producing text that supports a more material engagement and leads to better memory of the content, this needs to be balanced with the necessary digital skills that align with contemporary demands in society (Chapter 6, Korte & Körkkö). A variation of writing methods will strengthen the different stimulative embodied cognitive processes that learners must adopt to effectively use different writing substrates and their affordances. Learners must be supported from early on to develop balanced handwriting and typing skills so that they can play an active role in our digital world (Chapter 6, Korte & Körkkö).

When it comes to creative practices, such as arts and crafts, this book lifts the importance of learning by doing and making (Chapter 9, Groth & Gulliksen; Chapter 11, Groth) and material engagement (Malafouris, 2018). Also, this field is undergoing a shift in materiality that affects the way students and practitioners engage with materials and tools (Chapter 10, Søyland). Affordances of analogue and concrete materials are fundamentally different to the immaterial and digital tools and hybrid making that are introduced into the arts and crafts classrooms. While there is no doubt that digital technologies provide other potentials for making—some which surpass traditional means by far—there is a concern that this also brings challenges related to embodiment.

Central to arts and crafts education is that it offers unique possibilities to establish a dialogue with materials and connect with the physical world through engaging with it (Chapter 9, Groth & Gulliksen; Chapter 10, Søyland). In such a process, materials challenge us and provide different types of resistance or opportunities as we explore and interact with them. Additionally, craft practices offer arenas for safe failing and recovery—a process that builds resilience and endurance and the capacity to wait for rewards (Chapter 9, Groth & Gulliksen). A shift from physical real-world experiences like whole-body drawing to extensive use of digital technologies entails a shift in the learners' spatiotemporal relation with materiality. Analogue and especially whole-body drawing, for example, involves risk-taking and a real-world experience that digital drawing cannot offer. Teachers are encouraged to let pupils express themselves in varied ways and work in diverse types of formats and environments. Engaging pupils in, for example, large-scale drawing outside on a windy day or lying on the paper while drawing with charcoal, even in the dark, highlights the experience of thinking through drawing and connecting with the environment (Chapter 10, Søyland).

By externalising ideas into visual and 3D representations, students can extend their learning and thinking processes into the environment and make them concrete. In creative practices, the materiality of a situation can act as an epistemic medium, meaning that learning happens in the act of experimenting and reflecting through material means (Chapter 9, Groth & Gulliksen). The artefact progresses the enquiry but also visualises the process and the results of it. In this sense-making process, the hands often form the point of interaction

between person and material, as if thinking through the hands and the material (Chapter 9, Groth & Gulliksen). Additionally, by concretising conceptual ideas in matter and using materials as scaffolding tools in complicated systems, the learner can off-load cognitive tasks to the environment, as well as collaborate with others on the same tasks. Arts and crafts thus work as a premise supplier for other school subjects in which learners may test and engage with content knowledge in multimodal embodied ways. Artefacts that are formed as a result of longitudinal and personal processes of engagement may become very important for the learner or maker, as they carry and embody the process of engagement (Chapter 9, Groth & Gulliksen; Chapter 10, Søyland).

In craft learning traditions, such formative learning experiences extend into the socio-material learning context, involving learners in a community of practice (Lave & Wenger, 1991). In these conditions, the learner is culturised to embody not only manual skills but also habitual and gestural patterns and movements that are shared by practitioners in the same community, making a deep imprint on the learner's understanding of self and identity. Such culturation of the learner is not relevant in today's educational system, where learners are not aiming to be professionals in one area but rather interdisciplinary renaissance knowers of a large repertoire of subjects. However, apprentice learning may be utilised in more embodied explorations of a subject matter—for example, by contextualising a situation (Chapter 11, Groth). While visiting real studios and experiencing practices and materials in their right contexts would be preferable, using external resources to bring the experts to the students in an audio-visual form may help convey the context and situatedness of the practice. Carefully selected or created videos bring the world into the classroom and give a multimodal dimension to the practice under study (Chapter 11, Groth).

In sports, the role of the body and the more tacit forms of knowing in action are inevitable; here, thinking through action is at its most evident form. However, thinking consciously about how to make a certain action can distract from performing the task at hand, as the whole-body performance is building on muscle memory drilled through countless repetitions that have become automatic and implicit. Such drilling of the body to perform seamlessly and perfectly to achieve goals set by someone other than the performer has been the norm in many sports and physical education. However, such "pain for gain" thinking objectifies students for the purpose of curricular and political goals and might distance students from their sensitivity to their own bodies and the resonance between themselves and their environments (Chapter 16, Engelsrud). By attending to the psychophysical nature and sensitivity of a student, we can align better with the whole person and their needs and abilities in a more positive and compassionate manner, one that might advance the student's relation with their body and its capacities (Chapter 16, Engelsrud).

When engaging in activities that are performed while interacting with others, more than only one's own intentions must be considered. Dancing in pairs or acting and reacting in a dual constellation, such as in martial arts, one's own

actions must be dynamically performed at a high level of speed and precision—also involving bodily interpretations and improvised counter actions based on what the partner is doing. In such a "dance" of mutual interaction, there is no time to consciously think; instead, what happens is a simultaneous bodily reflection in and through action—the ultimate example of embodied cognition (Chapter 17, Ravn). Not only are we moved and affected by the partner in our interaction, but the event also has a life of its own, and the dynamic of the event as a whole "potentially shapes *and* transforms" pupils' movements and their embodied experience of these movements: the situation moves beyond control and potentially to the point of not knowing. In such situations, students may find themselves being danced by the dance, moved by their martial arts partner, or played by the game—a truly embodied interaction with the situation and the environment (Chapter 17, Ravn).

In music classes, static and preconceived styles of teaching that overrule the student's intentions and sensitive connection with the music and environment may be detected. In such teaching traditions, the primary concern is to teach musical notation, and formal music training is focused on learning to play precomposed scores on standardised instruments. Such an approach has led to thinking about music as a "thing" rather than an active and interactional process. By thinking of music-making as an activity, or as "musicking", teachers may invite pupils to engage with sounds and instruments in an enactive manner. When musicking, students not only interact with the instrument but also with the sounds it makes—a merging of the student's actions and interactions with the instrument that results in an audible environmental artefact. Listening to music is an embodied activity, exploiting the multimodal capacities of our whole bodies in taking music in and letting it move us both bodily and emotionally (Chapter 15, Jensenius).

New music performance technologies challenge traditional teaching settings in music. For example, laptop musicians often perform with software that works in both real-time and non-real-time modes, and for them, composing may also include building the instrument, further blurring the boundary between instrument maker and composer (Chapter 15, Jensenius). Some artists even release apps with multitrack versions of their songs that users can modify at will. This opens for more "active listening", in which the perceiver becomes a performer and participant as they actively engage with the musical material. Such new music technologies are not yet "classroom ready"; however, they carry much potential for thinking about music learning as an active engagement. Creating new music, even new instruments or ways of exploring sounds instead of learning ready-made chords, moves music education towards an embodied practice of musicking (Chapter 15, Jensenius).

Children's relationships to their natural environment have changed over time, from frequent and largely independent roaming in forests, green environments, and urban undeveloped lots to mainly indoor activities and controlled visits in nature designed by adults. Similarly, children more often learn about the natural environment in a classroom, while there are significantly

more experiential and embodied learning opportunities available when lessons are designed as situated and contextualised—for example, in a forest (Kiefer & Trumpp, 2012). There is an emerging field of nature-based learning approaches that encourage situated educational practices. While technologies can be partly blamed for the shift away from nature, technology may be used as a tool to enhance rather than diminish children's connections with nature (Chapter 13, Esbensen et al.).

Smartphones are a promising technology in the field of outdoor education: the use of nature apps, internet access, and the ability to have a camera, notebook, and audio recorder at hand can enable new child-led connections with nature, stimulating curiosity about the natural environment. Through engaging educational apps with built-in game-like motivation, pupils can earn badges as they identify and document different natural species. Teachers may thus place greater focus on the benefits of situated and embodied learning through the use of smartphones to teach pupils to be active and curious knowledge seekers through technology and science subjects that take place in nature (Chapter 13, Esbensen et al.).

Research on outdoor schooling suggests that natural environments stimulate perceptual processes critical to basic science learning. Scientific reasoning relies on sensorial and attentive empirical observations, hypothesis testing, and theoretical assumptions explored in experiments. In outdoor science explorations, perceptual and bodily interactions are embedded in the natural environments that are being studied. Equally, experiencing artworks may engage pupils in sensory experiences and reflection, offering alternative ways for engaging with natural and science-based phenomena (Chapter 14, Schilhab). By combining scientific exploration with aesthetic experiences, content knowledge may be opened in new ways. In a scientifically oriented art exhibition, a pupil may take their time to attend to and perceptually dwell on tangible phenomena and installations. Opportunities to engage in creative practices also offer means to process and embody the studied topic in new ways that give meaning on a perceptual level (Chapter 14, Schilhab).

Digital tools are here to stay, and the digitalisation of all aspects of society also means the integration of digital technologies in education. Not only is this affecting teachers' pedagogical approaches, but they also shape them. At the same time, as teachers struggle to keep up with technological advances and new tools, there is a need to prepare learners for tomorrow's technology-rich society (Chapter 12, Korte & Körkkö). In this context, it is important to take control of the tools and make them purposeful and relevant rather than using them blindly or for the sake of the imagined progression they are connected with. There is a need for embodied digital pedagogical practices that respect learners' emotions and have a holistic perspective on learning—and that are experienced as meaningful by both teachers and pupils (Chapter 12, Korte & Körkkö). Technology-enhanced, embodied learning environments and educational technology involving embodied learning designs derived from the 4E embodied cognition framework are being developed but still need

pedagogical infrastructures to be meaningful. This book introduces such a technology-enhanced embodied pedagogy while providing a reference for practitioners who seek to design technology-mediated learning experiences that link movement and learning objectives (Chapter 12, Korte & Körkkö). The teacher can still take advantage of the embodied learning approach with non-digital media or even without any media at all, as the world is inherently physical and full of potential for embodied interaction.

Theoretical subjects such as mathematics or sciences might at first seem like subjects that are less "embodied", using more intellect than body-based practical subjects, such as sports or arts and crafts. However, such division into the theoretical and practical subjects only reiterates already rejected dichotomies, such as body and mind. In fact, subjects that are thought of as more theoretical, abstract, or conceptual are also grounded in human-environment coupling and sense-making. By taking an embodied perspective in education, we may build on this understanding and utilise the afforded benefits. After all, these are not new phenomena—for example, mathematical computations have long been aided by externalising the task to beads, fingers, or numbers drawn on paper. Through this anthology, we would like to once and for all move on from thinking of some subjects as more important or relevant due to their relation to what is called intellectual subjects. Our message is that all learning is embodied in nature, whatever the subject matter.

Inspiration for your own practice

We have only covered parts of what an embodied cognition approach offers teaching. And maybe you have already anticipated or even trialled your interpretations of embodied teaching techniques in your own practice. If you are teaching physical education or an aesthetic discipline like music or visual arts, the leap to an embodied perspective is probably not far. On the other hand, if you are uncertain about where to begin because you are teaching disciplines that mainly take place in the classroom, paying attention to how to operationalise 4E(+) in your particular circumstance may be both revelatory and encouraging. We suggest that you begin by following the checklist below and take the time you need to carefully consider our guiding questions. This list is not meant to be complete; however, it provides a starting point from which you can develop your practice of embodied teaching.

Embodied cognition entails acknowledging that learning should literally *make sense* to the learner. This may come from engaging the learner in whole-body *enactive* activities involving sensory-motor activities which are known to promote well-being and motivation for learning. Whole-body activities inherently call upon learners to be alert and present in the moment by prioritising the perceptual element of the learning situation. An activity can stimulate all senses when pupils are allowed to move about in a natural environment rich in sounds, colours, and odours; shifts in ambient temperature, moisture, and light intensity; and typically also with uneven terrains. Natural environments

are also ripe with other organisms whose activities and daily life cycles often tacitly endorse the perceptual processing in the learner. Just think of how chirps from nearby birds, the swirling of insects, and the gentle stirring of leaves and grass by a passing breeze embrace us in a vibe of life even when we are not really paying attention to it.

Ask yourself whether the teaching you are about to do could actually take place outdoors, where your pupils could move about to investigate the environment, sharpen their perceptual acuity, or solve questions. How would you ascertain that the pupils engage in whole-body activities and that their stay in the multifaceted environment benefitted their perceptual and enactive minds?

A learning situation can similarly draw on aspects of the sensory-motor activity when pupils are requested to draw, dance or process their impression using, e.g., clay modelling, musicking, or cutting out cardboard shapes. Prioritising particular senses is just one significant asset when using aesthetic work as a didactic tool. Another is the unique turning of an impression into an expression for the learner. Here, sense-making is translated into material being, which helps the learner to mentally engage with, explicitly reflect upon, and thus increase the chances of retaining and later remembering what was learned.

Stimulating embodied cognition through aesthetic activities also fosters important introspection, preparing the pupil to get in touch with their own sensations, sentiments, and experiences of values, as well as their sense of responsibility for the creation and ownership of their learning. When transforming their feelings and values into something shared, these feelings become visible and tangible. In other words, the innermost comes into a recognisable existence that can be related to in novel ways.

Ask yourself if the learning situation you create would benefit from more silent contemplation accompanied by creative, reflective moments where pupils could draw on their own associations and inner values and feelings, which could later be shared with, e.g., classmates and family. Would the creative process and the actual end results aid in achieving the goals you have set forth for the lesson?

The setting where learning is occurring can be changed by incorporating spaces outside of school, such as the local area or a nearby street. Manipulating the learning space can also happen by visiting places like local businesses and science and cultural centres.

However, manipulating *embeddedness* does not have to be overly demanding. Try, for example, to do some teaching in a large shared space within the school, where pupils can organise their learning bodies in new ways and vary their postures or use music, light, or odours to accompany the teaching.

When teaching language, history, or physics, you could highlight themes and associations by wearing relevant clothes and maybe even ask your pupils to imagine what to wear or bring items of relevance to the subject. You could also involve them in role-playing, where they practice imagining the lives of historical or narrated persons. Consider how learning about gravity would take on an

emotional dimension if pupils were to reenact Newton's experience of a fallen apple together with laboratory work.

When you manipulate the learning environment by involving certain objects and artefacts, you are also *extending* the learning mind. You can use materials in the surroundings to reinforce particular mental states when they act as referents, e.g., in language learning. However, you can also use objects to fortify learning situations by providing concrete context for the learning. Objects are formidable as vehicles for associations and indispensable as a common third by which we can synchronise our shared understanding when using, e.g., graphics, globes, and various instruments.

Ask yourself whether the topic you are teaching may seem fairly intangible and would benefit from material anchors (Hutchins, 2005) that could simultaneously concretise and align your pupils' attention. Also, ask yourself whether you have offered sufficient connections between what the pupils embody and what they are supposed to explicitly understand or whether the learning would benefit from the many associations and inspirations that may occur when your pupils are exposed to concrete instantiations of theoretical content.

Obviously, changing a more traditional and sedentary learning environment to support an embodied activity is not trivial. The switch depends on much more than imagining new ways of teaching. Time, economy, and specific school cultures may hinder changes to your teaching techniques. Also, school administrators, parents, colleagues, and even your pupils may challenge the feasibility of implementing teaching inspired by the embodied cognition approach. It is highly conceivable that pupils of a certain age need to learn what you aim for by these radical changes in order to understand what is expected of them and how they should behave when learning regimes are no longer restricted to sitting passively at a desk in the classroom. As with all educational approaches, the dynamics and logic of the working processes need to be adopted by the pupils to work effectively.

However, even minor changes—like wearing clothes inspired by historical sites and ages, having pupils draw and express what they experience, or engaging pupils in role-playing activities to simulate and reflect on life worlds that are different from their own—can make a wonderful impact. Hopefully, the occasional successful implementation of embodied approaches prepares the education system for more pervasive changes in due course.

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