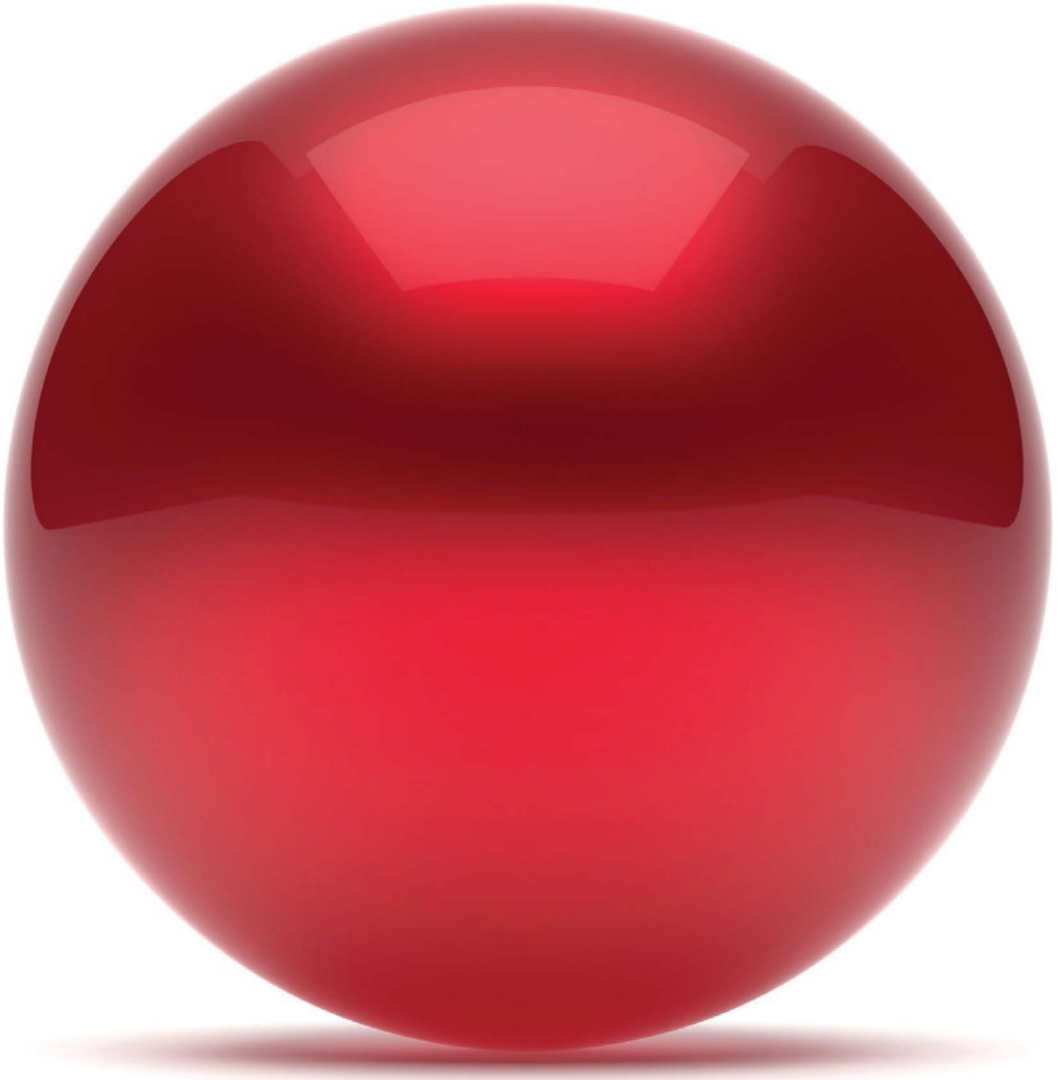
Educational Technology and Polycontextual Bridging

Eyvind Elstad (Ed.)



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SENSE PUBLISHERS
ROTTERDAM/BOSTON/TAIPEI

A C.I.P. record for this book is available from the Library of Congress.

ISBN: 978-94-6300-643-9 (paperback)
ISBN: 978-94-6300-644-6 (hardback)
ISBN: 978-94-6300-645-3 (e-book)

Published by: Sense Publishers,
P.O. Box 21858,
3001 AW Rotterdam,
The Netherlands
https://www.sensepublishers.com/

All chapters in this book have undergone peer review.

Printed on acid-free paper

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PREFACE

This book publishes results from a new research project funded by the Norwegian Research Council entitled *Learning in the 21st century: Capitalising on students' digital strengths; compensating for desired capabilities*. The research project produces research and knowledge relevant to student teachers, teachers, school leaders, researchers and other individuals with an interest in the use of information and communication technology in school. The book is thus aimed at the academic world and the teaching field and at policy-makers and other socially minded individuals. The editor is grateful to two anonymous referees for their careful reading of the chapters. Their contributions to the improvement endeavour have been decisive. This project became the last fulfilled research project initiated by Gavriel Salomon. Gavriel Salomon—or Gabi among friends—died untimely on 4 January 2016. An up-to-date version of Salomon's masterpiece "It's not just the tool, but the educational rationale that counts" is included in this volume. The book ends with chapters which express tributes to Gavriel Salomon as an academic scholar.

EYVIND ELSTAD

INTRODUCTION

Technology has become ubiquitous in nearly every contemporary situation, while digital media have acquired considerable importance in the lives of young people. Alongside their interest in digital media, schooling constitutes a core component of the life of children and adolescents. Youth's use of digital media creates tensions between traditions and expectations of renewal within the school. The once-sharp divide between school and leisure time is eroding. Will and how can the school as an institution relate to this comprehensive process of change known as the digital revolution? How can the school build a bridge between the world of youth and school material to enable students to learn in a new digital age? This endeavour is named *polycontextual bridging* in this book. What are the good examples of polycontextual bridging? What novel educational goals can be achieved by net-related activities when incorporated into the school, and how can out-of-school learning be successfully framed by educational purposes? These questions are addressed from different perspectives by several scholars in this book. The chapters in this volume offer an up-to-date discussion on the challenges, as well as the possibilities, of technology use in school education. In tackling the critical issues created by technology, this book provides an important resource for student teachers, teachers, education scholars and those interested in a critical examination of digital expectations and experiences in school education. This book is motivated by a pressing need to come to grips with the dilemmas caused by an apparent clash of learning cultures in the individual classroom, in the schools, in the education of teachers, and in the institutions of teacher education. The book is also a tribute to Gavriel Salomon and his research on the cognitive effects of media's symbol systems, media and learning, and the design of cognitive tools and technology-afforded learning environments. The book consists also of his masterpiece "It's not just the tool, but the educational rationale that counts". Further, three internationally recognized experts – Howard Gardner, David Perkins, and Daniel Bar-Tal – describes Salomon's remarkable academic contributions.

This book is an attempt to explicate, illustrate, and critically examine the idea of polycontextual bridging between youth's leisure cultures and school material to enable students to learn in a new digital age. The authors do not present a common front on the complex question of the proper use of information and communication technology in the school but instead present a diversity of arguments and viewpoints. The book is an attempt to raise questions and start a debate.

The demise of traditional schooling has often been predicted based on the assumption that media-related developments will explode it apart and revolutionise thinking about education. The 21st-century student has experienced the shift from the world of writing and the book to the world of images and the screen. Political expectations for the modernisation of schooling through the use of information and communication technology and the allocation of funds in accordance with politically created agendas have led to perceived pressure on school staff to employ information and communication technology as a teaching aid.

The chapters in this volume offer a thorough, up-to-date discussion on the challenges of technology use in school education. In tackling the critical issues created by technology, this book provides an important resource for student teachers, teachers, education scholars and those interested in a critical examination of digital expectations and experiences in school education.

Why a New Book on Information and Communication Technology in the School?

Books dealing with the use of information and communication technology (sometimes abbreviated ICT) in the school have been published over the years. Is there any need for a new book on this phenomenon?

Firstly, this book publishes results from a new research project funded by the Norwegian Research Council entitled Learning in the 21st century: Capitalising on students' digital strengths; compensating for desired capabilities. This research project produces research and knowledge relevant to student teachers, teachers, school leaders, researchers and other individuals with an interest in the use of information and communication technology in school. The book thus is aimed at the academic world and the teaching field and at policy-makers and other socially minded individuals.

Secondly, the nature of source criticism and critical thinking has changed in the digital world (Buckingham, 2013). A core goal of the school system is to prepare pupils to become citizens with critical-thinking ability, so they can better detect lies and manipulation in the digital world. Schools must help pupils become critical consumers of Internet services and electronic media, helping them make informed decisions and avoid harmful pitfalls. The emphasis on rhetoric in Norwegian courses is an example of such education: 'The aims of the studies are to enable pupils to explain the argumentation employed in non-fiction texts by applying their knowledge of rhetoric' (Directorate of Education and Training, 2006). In part I of this book, the interested reader will find several chapters on how schools can build bridges between the techno-fixated world of pupils and the mandate of the school.

The study of information and communication technology in the school needs constant renewal as the ways in which technology is used are constantly changing. Renewal is seen in the improvement of learning tools and the development of better analytical tools for understanding how a learner learns by using information and communication technology into use. For example, consider Norwegian educational

authorities' new focus on learning analytics (Ferguson, 2012; Siemens & Baker, 2012). The Ministry of Education and Research wishes to build a new area of expertise:

> Learning analytics means measurement and analysis of learning while it takes place. The goal of this type of analysis is a better understanding of how learning occurs and of how provision can be made for the best and most effective possible learning. A variant of learning analytics relates to the use of digital tools. With the help of such analysis, computer programmes can, for instance, customise learning for the individual user. Learning analytics are thus of great interest to the researcher but may also be used to improve classroom teaching. (Ministry of Education and Research, 2015, p. 1)

The expectations for the use of educational technology in education are great.

The development of innovative educational computer programmes in recent years is promising. For instance, some programmes simulate how a car engine works and what happens inside the engine when the car moves. This animation demonstrates how the internal combustion engine works and can help the learner to construct a mental model of the engine's operation. Similar innovations simulate the operation of an electrical circuit (Kollöffel & de Jong, 2013), a macro-economic system (Pozo-Barajas et al., 2013) and gene mutation, which is usually hidden from observation (Smetana & Bell, 2012). Such technologies can work well in learning technical materials which it is generally not possible to observe in everyday life. However, the effect on learning depends on how the learner uses the digital representation to better understand complex phenomena (Freeman et al., 2014). Two chapters in this book discuss the use of educational games.

Another justification of this book is the growing need of students' critical assessment of use of information and communication technology (Salomon in Chapter 8):

> Empowering young people to become full participants in today's digital public space, equipping them with the codes and tools of their technology-rich world, and encouraging them to use online learning resources—all while exploring the use of digital technologies to enhance existing education processes …— are goals that justify the introduction of computer technology into classrooms. (OECD, 2015, p. 186)

Pupils need to be critical users, especially when using the Internet as a means of accessing information (Milson, 2012). For instance, in social studies, students can use the Internet to study authentic texts and make critical judgements of their validity (Shiveley & VanFossen, 2012). However, information available digitally might have been posted online with the express intent of propagating incorrect information. Therefore, the ability to critically analyse information is important for the individual, as well as society. The International Association for the Evaluation of Educational Achievement promotes a broad concept of this ability, defining

computer and information literacy as 'an individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in society' (Fraillon, Schulz, & Ainley, 2013, p. 17).

The availability of information and communication technology in the school has a multitude of effects and provides no magical formula for attaining better and more intelligent learning. This, instead, emerges as deep, conceptual understanding and higher-order thinking. The endeavour to produce this learning 'requires intensive teacher-student interactions, and technology sometimes distracts from this valuable human engagement' (OECD, 2015:3). We clearly need greater knowledge of how we should make use of information and communication technology within the school, as well as how to avoid the unfortunate effects. This book is a contribution to meet this need.

DISSENTING OPINIONS ON TECHNOLOGY USE IN SCHOOLS

From time to time, heated debates regarding the use of information and communication technology in the school arise among parents, politicians and educators. This is as it should be in a democracy. Powerful commercial interests promote the idea of I-pads or tablets for all pupils and smart boards in all classrooms. Most people have strong views on information and communication technology, and many feel qualified to express these views. The purpose of this collection of chapters is to present research relevant to understanding of and debates on information and communication technology in the school. I have asked leading educational researchers to shed light on different aspects of this topic. The authors do not present a common front on the complex question of the proper use of information and communication technology in the school but instead present a wide diversity of arguments and viewpoints. Authors are responsible only for the content of their own chapter, but all the chapters are based on the academic principles of objectivity, restraint and investigative factuality. It is my belief that these qualities will improve the debate regarding the ideals of good education.

Differing opinions regarding the use of information and communication technology in the school abound: should it be introduced in small steps or great leaps? Are all forms of educational renewal based on information and communication technology beneficial? Does increased use of information and communication technology, in fact, lead to educational improvements? What implications does the use of technology within and outside the school have for the in-depth learning necessary to understand the material in core academic subjects? These are a few amongst many questions. Those who work in the school system—teachers and school leaders—have differences of opinion on these and many other issues. There also appear to be generational gaps in teachers' views of using information and communication technology in teaching (Elstad, 2006). Generational differences, however, stand as only one of several different contributory factors. More knowledge

of teachers' attitudes towards the potential use of information and communication technology in the school is needed.

It is tempting to believe that research can determine once and for all whether information and communication technology promotes better learning. Sadly, this is not the case as that general question is dependent on a large number of factors. By asking more specific questions, though, research can provide some insights into how information and communication technology can either serve as tools for better and smarter learning or stifle learning. Normative questions about the nature of future schooling depend on what values that, at the most fundamental level, we wish to promote. In considering this kind of question, researchers are on equal footing with other citizens in determining what constitutes a good school. It is our hope, however, that the interested reader will find in this book a better foundation for understanding the potential uses and pitfalls of using information and communication technology in the school.

ACKNOWLEDGEMENT

The book is funded by grant no. 218245 from the Norwegian Research Council.

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PART I

EDUCATIONAL TECHNOLOGY AND POLYCONTEXTUAL BRIDGING

THOMAS ARNESEN, EYVIND ELSTAD,
GAVRIEL SALOMON† AND LARS VAVIK

1. EDUCATIONAL TECHNOLOGY AND POLYCONTEXTUAL BRIDGING

An Introduction

BRIDGING BETWEEN YOUTH CULTURES AND SCHOOL CULTURE

Digital media has a growing importance and it affects people's communication habits and patterns and their attitudes towards school learning. We need greater understanding as to how learning takes place in various arenas, how these arenas dynamically interact, and how this affects the educational environments. The chapters in this part of the book contribute to our understanding of these phenomena. The underlying assumption is that the education system's monopoly on knowledge is being challenged because information is readily available to a growing number of people, thus highlighting schools' representations of knowledge, modes of learning, forms of practice and basic values in relation to knowledge production. Moreover, emphasis shifts today from simple mastery of knowledge to the mastery of 21st Century skills which school needs to prepare for (e.g., Griffin, McGaw, & Care, 2012; Pellegrino & Hilton, 2013; OECD, 2011; Thomas & Brown, 2011). With the prevalence of the new media, communication shifts from print to the visual, strongly affecting the modes of representation and with them – the nature of learning (e.g., Kress & Selander, 2012; Danielsson & Selander, 2016). We need more systematic knowledge of how educators in practice can integrate the life-world of children and adolescents, and the totality of their life experience, into pedagogical activity. It is necessary to study which ways help to increase motivation and improve learning outcomes.

NEW MEDIA, NEW SKILLS, NEW CHALLENGES FACING SCHOOL

Learning is often associated with what is going on in schools and universities, and in museums, galleries and science centers outside school. What need not be overlooked, however, are out-of-school activities and learning via various digital media. New media, such as Facebook, YouTube, Twitter, and the Internet in general, can be the sources of much learning (Beavis, 2013). However, it is radically different from and apparently greatly preferred by youngsters over regular, disciplined and

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intellectually- and future-oriented school-based learning (e.g., Oblinger & Oblinger, 2005; Ito et al., 2010).

The differences between in-school traditional learning, designed to acquire disciplined knowledge and intellectual, rational skills, and out of school, net-related and friendship-driven learning is too large to be ignored. Thus, while school-based learning needs to capitalize on the current generation's digital strengths, it has to compensate that generation for what it lacks: The acquisition of disciplined knowledge and scientific thinking skills

An expected educational revolution is based on the idea that the 21st century student has experienced a shift from the world of writing to the world of images and from the world of the book to that of the screen (Bagdikian, 2014). That student has thus acquired a whole new set of skills, preferences, and knowledge, fundamentally different from the traditional print-based world. Teachers are seen as digital immigrants, as opposed to the students who are the digital natives (Palfrey & Gasser, 2013).

Important differences between education and other kinds of learning have been noted. School has long been criticized for developing inert knowledge as opposed to knowledge which is readily applicable in "real life" (Whitehead, 1929). Differences are identified between the primacy of "pure thought" activities in school vs. tool-based activities outside, and individual activities in-school vs. collaborative activities out-of-school (Resnick, 1987). Relatedly, learning from the new media is based on free choice, is often game-like, is rarely intellectually challenging, does not require the same kind of mental effort as school learning, and is often self-regulated and socially interest- or friendship- motivated. Unlike education, it is not future-oriented, it is voluntary and not governed by any adult authority; it is self-determined and its contents are concrete and highly contextualized. Moreover, the net-culture is based less on accumulated knowledge and more on skills such as games based problem solving and digital literacy. In contrast, education always entails a specific content that the students learn for particular reasons, and those involved learn from someone. This suggests that it is important to distinguish between learning cultures and educational cultures, where educational cultures are learning cultures framed by purposes (Biesta, 2016).

Bernstein's (2000) distinction between horizontal and vertical knowledge is relevant here. Horizontal knowledge, usually acquired out of school, is highly contextualized, concrete, embedded in actual practice, and directed at immediate and specific goals. Vertical knowledge, on the other hand, is more often school-based and thus principled, decontextualized, coherent, explicit, systematic and relatively abstract. The implication is that the two kinds of knowledge, distinguished from each other mainly by their respective structures, not just location, are incompatible in their pure form; horizontal knowledge, typical of the net-culture, does not prepare for systematic academic study and achievements (Bennett & Robards, 2014; Williamson, 2013). Similarly, it is claimed that the traditional school culture does not prepare for proper functioning in the 21st Century (Thomas & Brown, 2011).

On the one hand, there is the world of the printed word with its emphasis on logic, sequence, history, exposition, objectivity, detachment, and discipline. On the other, there is the world of "screens" with its emphasis on imagery, narrative, presentness, simultaneity, intimacy, immediate gratification, and quick emotional response. According to Postman (1993), children come to school and the world of the printed word having been deeply conditioned by the biases of "screens". He states that "a sort of psychic battle takes place, and there are many casualties – children who can't learn to read or won't, children who cannot organize their thought into logical structure even in a simple paragraph, children who cannot attend to lectures or oral explanations for more than a few minutes at a time" (16) He claims they are failures, but not because they are stupid, but because there is a media war going on, and they are on the wrong side – at least for the moment.

In light of the alleged differences between the Net and the school cultures, a debate has emerged between those who advocate a total change of the school culture in line with the Net culture, and those who would rather find a way to bridge between the two. On the one hand we have those who argue that all knowledge can be acquired "on the fly" through the open-ended, voluntary Internet-based out-of-school activities. Based on the idea that the 21st Century student has acquired a whole new set of skills and knowledge, fundamentally different from the traditional print-based world, proponents of this view expect an educational revolution (Beavis, 2013).

Recent research on out-of-school settings focuses on how children and adolescents operate in the media ecology (Buckingham & Willett, 2013; Blumberg, Blades, & Oates, 2015). Variations in use are conceptualized as being associated with friendship-driven or interest-driven communities of practice (Ito, et al., 2010). School is being criticized for not including or valuing the emerging new media literacies and associated genres of participation. Some advocate the integration of new modes of learning, so-called game literacy, into school learning (Gee, 2014). And some consider new media literacy in light of active media participation (Mihailidis & Thevenin, 2013). Buckingham and Willett (2013) sees this as symptomatic of a much broader phenomenon – a widening gap between children's everyday life worlds outside of school and the emphases of many educational systems. The overall message is that school cannot remain as it is today and has to confront the Net-culture.

On the other hand, there were those (e.g., Elstad, 2006; Elstad, 2016) who questioned, first, the extent to which one can speak of a whole generation of Net-natives while in fact only a few may have truly developed different needs, preferences, abilities and ways of learning. Also, large socio-economic differences have been observed (Ito et al., 2010). Second, Bennet and Maton (2010) argue that similar claims to totally convert school to fit the new media have been made in the past in light of the visual dominance of TV. Yet, school succeeded to beneficially incorporate the new media of that time without losing its adherence to its main mission. And third, the kinds of out of school Net-related activities are unlikely to

prepare students for academic learning as they are not applicable to tasks requiring systematic thinking and critical evaluation of semi-abstract material (e.g., Vavik & Salomon, 2015). In short, as stated by Bennett and Maton (2010), trying to make school more like the Net-based culture de-privileges it, teachers and knowledge, "while valorizing the attributes of the tech-savvy student" (p. 325).

IN- AND OUT OF SCHOOL LEARNING

An important rationale for introducing ICTs in schools was to bridge the gap between in- and out of school learning. ICT offered new possibilities for students to work collaboratively in solving authentic problems beyond the limits of the school environment (Brown, Collins, & Duguid, 1989). Across many countries schools have equipped themselves with information technologies, Internet access and mobile devices so they can teach on the students' technological territory. There were high expectations, promising profound improvements in education as a function of technology afforded pedagogy. However, with the exception of a few islands of excellence (e.g. Linn 2013), findings repeatedly show that the infusion of ICT into school learning is relatively disappointing (e.g., OECD, 2015).

In light of these findings we need to distinguish between the adoption of ICT open tools into school culture which does not really change, and the transformation of school which takes into serious account the Net-culture. The difference between in- and out-of-school practices is thus not primarily about whether or not technology is used, but the overall cultural, social and situational context of usage and the anticipated learning trajectories and outcomes. We are familiar with adoption of tools, but far less so with school transformation.

In formal school settings, digital technologies are usually seen in relation to the attainment of well accepted educational goals, or the exploration of novel educational objectives, e.g. new semiotic modes of expression (Kress, 2015). Of particular interest is mind-tools as a set of open-ended tools for constructivist learning by students using dynamic modeling tools, multimodal construction, conversation tools, information interpretation tools, hypermedia construction and semantic organization tools (Yang et al., 2015; Spector et al., 2013; Rucker, 2013). However, do these examples constitute the transformation of the school culture? Indeed, the concept of school transformation requires much explication based on the examination of existing exemplary cases. One of the purposes of the chapters in this book is to analyse such cases of schools and classrooms where the school has become transformed, thus bridging between the two cultures.

Several basic assumptions must be emphasized. The first assumption is that education is not about the adjustment to 'what is,' but requires judgments about whether 'what is' is educationally desirable. As Symour Sarason (1984) argued: "Not everything that is possible is necessarily also desirable". This is why it is important to ask to what extent, in what ways, and under what conditions the opportunities

offered by the global networked society are educationally beneficial and when they are not (Biesta, 2016).

The second assumption is that mastery of disciplined knowledge, together with socialization and person-building, are still essential for proper and intelligent functioning in the knowledge society (Biesta, 2016; Gardner, 2012). As Selton-Green (2004) declares in his conclusions, "Nothing is going to replace the importance of schools in educating the young in our society, not is any other system likely to be able to play a role in overcoming social inequalities" (p. 32). Or as stated by Biesta (2011): "If you don't know anything you fall for everything". As pointed out by Larry Sanger (2010), for accessing knowledge one needs an organized knowledge base without which one would not know what to search for. Access greatly depends on existing knowledge. Participation (Greeno, 2011) does not function for its own sake but for the purpose of learning which it can support and scaffold. Thus, serious attention to both the participation and the acquisition metaphors of learning (Sfard, 1998) is required. Each of the two metaphors has something of value to offer and not looking at both give exclusivity or dictatorial dominance to one.

A third assumption, related to the second one above, is that the acquisition of 21st Century skills is currently becoming increasingly important and their mastery is going to serve as the main focus in international assessment of education by the OECD and its PIACC program, and hence – the new emphasis in schools. Among the skills mentioned are problem solving, critical thinking, team work, creativity, research, local and global citizenship, and more (OECD, 2011). 21st Century skills of the kind mentioned above are acquired via the active acquisition of the scientific disciplines, not independently of them (e.g., Biesta, 2016; Sanger, 2010).

EDUCATIONAL TECHNOLOGY AND POLYCONTEXTUAL BRIDGING

Based on these assumptions, the conception of *bridging* can be taken into consideration how formal education can utilize the genuine engagement and motivation, skills and knowledge acquired in the media ecology in an educational context. In the process of selection and refinement of elements from the informal to the formal sphere, what needs to be filtered out, what elements lose their original sense of meaning and motivation when framed in a school context, and what gems remain? Youth's use of digital media creates tensions between traditions and expectations of renewal within the school. The once-sharp divide between school and leisure time is eroding. Will and how can the school as an institution relate to this comprehensive process of change known as the digital revolution? How can the school build a bridge between the world of youth and school material to enable students to learn in a new digital age? This endeavor is named *polycontextual bridging* in this book. What are the good examples of polycontextual bridging? What novel educational goals can be achieved by net-related activities when incorporated into the school, and how can out-of-school learning be successfully

framed by educational purposes? These questions are addressed from different perspectives by several scholars in this book.

With the prevalence of the new media, communication shifts from print to the visual, strongly affecting the modes of representation and with them – the nature of learning (e.g., Danielsson & Selander, 2016). This book contributes to a better understanding of how teachers in practice can integrate the life-world of children and adolescents, and the totality of their life experience, into pedagogical activity. The aim of part II of the book is to discuss ways in which to bridge the alleged gap between learning in informal and formal contexts, what novel goals can they serve, and how can educational cultures be developed in the digital age towards sustainable educational learning. In other words, the purpose is to see how school can capitalize on students' web-based strengths while compensating them for that which the net-culture does not provide: Vertical and disciplinary knowledge. There are developed research and development projects which attempt to bridge the alleged gap, and do so in interesting ways.

The purpose of the following chapters of this part of the book is to examine these issues in depth, as well as the cultural context in which they operate. Kristiina Kumpulainen and Anna Mikkola discuss in Chapter 2 the discontinuities between in- and out-of-school learning in the digital age. While drawing on the sociocultural, ecological and discursive perspectives, they identify attributes of 'formality' and informality' in social activity, explore their relationships, and identify their effects on learning and education. In doing so they propose a hybrid learning model to education that creates bridging, navigational and transformative spaces for educational engagement, learning, identity, educational conditions and consequences of hybrid learning.

Kumpulainen's and Mikkola's chapter relies on a research project entitled 'Learning Bridges' at University of Helsinki. The project named 'Learning Bridges: Learning and Teaching at the Intersection of Formal and Informal Learning Environments' investigated and developed teaching and learning practices and models at the intersection of formal, informal and non-formal contexts. Of specific interest are learning environments situated within and across schools, museums, science centers and libraries. The Learning Bridges project develops pedagogical approaches and models in order to enhance productive collaboration between participants and contexts. The aim of this research project was to bridge gaps between formal and informal learning environments so that the funds of knowledge as well as social practices developed in one setting can become resources in the other.

Lisbeth M. Brevik (Chapter 3) present an analysis of a group of boys in upper secondary school who are poor readers in Norwegian as their first language (L1), but good readers in English as the second language (L2); a highly unusual combination. These students present a challenge to reading research as well as reading instruction, since the analysis indicates that these boys clearly separate between in- and out-of-school uses of English. Based on this study, Brevik argues

that, since the students do not seem to transfer their English reading skills from one context to another, teachers need to make this connection for them. As argued in this chapter, the students can profit from instruction that to a greater extent draws upon their interests and engagement, particularly their daily use of English in online gaming activities.

Ingvill Rasmussen's chapter (Chapter 4) reports on research projects in which researchers, technology developers and teachers designed a microblog service to support teachers' subject practices and create a greater number of good-quality dialogues in the classroom. The specific aim was to draw on the message format called microblogging to support the teachers' work as discussion facilitators by providing awareness of the pupils' work and to provide a representation of this for whole-class conversations. The analysis reveals how the teacher appropriated microblogging and identifies features that were particularly central in creating a productive culture for learning. The teacher used the blogs as a partner and participant to act and interact through to pursue the goals of the session and the students' microblogs provided a representation of the groups' collective thinking and, as a product made visible, this was referred to and elaborated on in the collective whole-class discussion. This chapter originated in the TWEAK project (acronym of "Tweaking Wikis for Education and Advancement of Knowledge" which is funded by ITU). This project develops models that balance learner exploration and negotiation with more goal directed efforts to bring knowledge advancement more up front in school subjects. The objectives TWEAK are to match collectively oriented tools such as wikis with tasks that require collaborative efforts and to address the role of the teacher as a most vital force in designing and supporting activities conducive to knowledge advancement.

Furberg and Dolonen's chapter (Chapter 5) focuses on the significance of teacher support in settings where primary school students engage with technology-based learning in the context of school science. They particularly scrutinise the roles of procedural and conceptual support. Procedural support involves guidance in the form of helping students regulate their work processes, whereas conceptual support refers to guidance in the form of helping students make sense of the scientific content (i.e., the concepts or processes) associated with the scientific theme at issue. By taking a dialogic approach, the study aims to explore the role of teacher support in technology-based learning in science education by directing the analytical attention towards the various forms of teacher support, and their potential roles in supporting students' development of conceptual understanding. The empirical basis of the study is a science project about the human body involving a class of primary school students and their teacher. Based on detailed analyses of student – teacher interactions taking place through various learning activities within the project, the study demonstrates some of the potentials and challenges accompanying these types of learning settings. This chapter originates from the research project ARK&APP – funded by The Norwegian Directorate for Education and Training. This project investigates the use of educational resources in the planning, conducting

and evaluation of teaching in four school subjects; Mathematics, Natural science, English (as a foreign language) and Social science. This project investigates 12 qualitative cases via observing how educational resources are used during lessons, with particular attention to how different resources generate engagement in different forms of student-teacher interactions. However, in this book contributions on the use of educational resources in Mathematics, and Natural science are represented.

Kluge's chapter (Chapter 6) relies also on the research project named ARK&APP. Kluge argues that using games in school may be a way to bridge home and school activities for the gaming generation. Two classes (5th and 8th grade) are observed in this mainly qualitative study, as they use games to learn algebra. The investigation concerns engagement, relation between game learning activity and school learning, and how bridging happens and contribute to school learning goals. The study show engaged and active students on a level that is atypical in a Norwegian math class, yet the curriculum-relevant achievements are slim. The gaming mode of trial and error the pupils bring with them from leisure gaming seems to hamper reflective learning processes. An interesting and promising finding is that the pupils strive to find the logic governing the games.

In Chapter 7 Andreas Lund summarizes generalizable attributes of good examples of bridging and distils nuances and findings, for instance, that a long-recognised educational principle is that the starting point for teaching has to be the learner's current situation. Lund shows that the chapters in this part of the book not just as separate studies, but also across in order to identify how cases demonstrate successful bridging as well as unfulfilled potential, one is struck by the complexity involved. He argues that bridging and the many forms of boundary work show that this is far too demanding to leave to pupils alone to handle and that successful bridging requires transformative agency and a view of technologies as artifacts, as well as environments where socialization and identity formation take place. He finds serious implications for teacher education, as well as for the professional development of practicing teachers and claims that successful bridging is very much a matter of teachers designing extended learning environments and trajectories where cultural resources and potential *polycontextuality* form the core of the design together with the learning object. An important endeavor is building on students' strengths instead of mainly repairing their weaknesses as isolated traits. Such an effort is necessary if schools are to tap into the many social and material resources that abound and retain their ecological validity in a quickly progressing knowledge society.

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KRISTIINA KUMPULAINEN AND ANNA MIKKOLA

2. TOWARD HYBRID LEARNING

Educational Engagement and Learning in the Digital Age

INTRODUCTION

The discontinuities between in-school and out-of-school learning have been the source of robust scholarship since the early 20th century (e.g., Dewey, 1916; Kilpatrick, 1923, 1925). Research has illuminated differences in people's abilities to solve problems across settings, illustrating that engagement and learning can vary significantly by context (e.g., Lave, Murtaugh, & de la Rocha, 1984; Nasir, 2000; Nasir & Hand, 2008; Resnick, 1987; Saxe, 1991, 1999). Lately, examinations of the discrepancies between learning in academic and everyday settings have been enriched by discourses that address the changing role of digital technologies and media in society and how this shapes the ways in which young people engage, learn, and build their identities in the digital age. Concerns about the growing disconnect between the *digital learner* and school have revitalized public conversations and academic research on the mismatch between in-school and out-of-school learning more widely (Erstad & Sefton-Green, 2013).

Efforts motivated by the need to make schools more relevant for 21st century students and, conversely, to make students better prepared for the 21st century, have resulted in explorations of the ways in which discourses, literacies, and social practices of the so-called "Net Generation" can be meaningfully and powerfully bridged with formal schooling (e.g., Hung, Lee, & Lim, 2012). In some of these efforts, school was envisioned as a fluid, self-fashioning, digital learning arena that is increasingly network-based, spanning boundaries between in-school and out-of-school sites of learning. Specific attention has been paid to interest-driven learning that guides students' learning activities toward educational, vocational, and civic goals (Ito et al., 2013). In contrast to these optimistic views, there are others that seriously question whether youth media cultures can legitimately enrich school objectives, envisioning scenarios in which digital media might hinder, distort, or even destroy what a school is and should be about (Postman, 1993).

This chapter was motivated by the need to further explore *funds of knowledge*: educational conditions that harness the media practices, discourses, and literacies embedded in young people's life-worlds. Drawing from sociocultural, ecological, and discursive perspectives, our chapter introduces a hybrid approach to learning and education through which existing disjunctures between academic (formal) and

E. Elstad (Ed.), Educational Technology and Polycontextual Bridging, 15–37.
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everyday (informal) learning can be re-framed to reconcile their traditionally divisive distinction. In our approach, *formal* and *informal* are not conceptualized as discrete categories, but rather as attributes present in all circumstances of learning, including the institutional contexts of schools (Holt, 1964). The priority for our research, then, was to identify these attributes, explore their relationships, and examine their effects on learning and education.

We will explain our approach via two empirical case studies from Finnish education that illustrate efforts to create hybrid learning opportunities. These cases share the joint goal of embedding students' life-worlds, including technology and media practices, in formal education. In our analysis of these cases, we will reveal how attributes of formality and informality intersect in students' learning activities. We will also provide a synthesis of the features of the cases in terms of their educational designs. Lastly, we will extend our discussion to include the potential implications of hybrid learning on student engagement and learning, and on schooling in general.

TOWARD HYBRID LEARNING

Education researchers have increasingly drawn attention to the ways in which the intersection of various discourses and social practices potentiates the creation of new forms of dialogue and negotiations of meaning. It is considered crucial that educational practices provide students with opportunities to draw upon the various life-spaces they inhabit (Daniels, Edwards, Engeström, Gallagher, & Ludvigsen, 2010; Ludvigsen, Lund, Rasmussen, & Säljö, 2010; McLeod & Yates, 2006; Phelan, Davidson, & Cao, 1991). Here, learning is understood as a holistic experience of participation situated within a matrix of multiple sociocultural contexts, not as something that takes place exclusively in one context, such as in formal education (Hughes, Jewson, & Unwin, 2007; Ramsten & Säljö, 2012). The challenge for education, then, is to create spaces for learning in which participants are able to engage in collective activities by sharing and critically examining their material, sociocultural, linguistic, and cognitive resources as embedded in their relative social ecologies (Akkerman & Bakker, 2011; Grossen, Zittoun, & Ros, 2012; Gutiérrez et al., 1999).

In our research, we are interested in a type of hybrid learning in which formal and informal funds of knowledge intersect and transform young people's engagement and learning. It is a space "in-between" (Bhabha, 1994, p. 1) several different funds of knowledge and discourse that can be both productive and constraining in terms of social and cultural practices – and, ultimately, one's sense of self and identity development. The notion of *hybridity* can thus be applied to the integration of different and sometimes competing knowledges and discourses: to the texts one reads and writes; to the spaces, contexts, and relationships one encounters; and even to a person's identity enactments and sense of self. Bhabha (1994) has used the term *third space* in his critique of modern notions of culture. He argues that a "Third Space … constitutes the discursive conditions … that ensure that … even the

same signs can be appropriated, translated, re-historicized, and read anew" (p. 37). Bhabha's argument is that the third space is produced in and through language as people come together, and particularly as people resist cultural authority, bringing different experiences to bear on the same linguistic signs or cultural symbols and, conversely, bringing different signs and symbols to bear on the same experiences. Opposing categories open up new alternatives (Bhabha, 1994); as such, in a hybrid space, oppositional categories work together to generate new knowledge, new discourses, and new forms of literacy.

ENGAGEMENT AND LEARNING FROM THE SOCIOCULTURAL PERSPECTIVE

Our hybrid approach to learning is guided by sociocultural, discursive, and ecological perspectives (Barron, 2006; Bloome, Carter, Christian, Otto, & Shuart-Faris, 2005; Castanheira, Crawford, Dixon, & Green, 2001; Cole, 1996; Kumpulainen & Renshaw, 2007; Vygotsky, 1978). We understand learning to be a social construct that emerges in interaction as learners engage in various formal and informal activities mediated by different communities, participants, rules, instruments, and artifacts. In the sociocultural approach, rather than conceptualizing learning as an epistemic process, it is instead considered to be inseparably linked with existential and socio-emotional processes involved in transforming identities and developing agency (Packer & Goicoechea, 2000).

In this hybrid approach, learning and development is understood as the acquisition and expansion of a cultural toolkit based on involvement in a range of specific cultural communities. According to the sociocultural perspective, culture is a situated resource – a fund of knowledge and a repertoire of practice – that individuals draw upon to make sense of their social and material worlds and to participate in them. Engagement and learning become evident and are continuously reconstructed in the social life of different communities, and are reflected in legitimate participatory and communicative ways (Vygotsky, 1962, 1978; Wells, 1999; Wenger, 1998). Learning is thus defined as the ability to distinguish between different contexts and their discourses, as well as the capacity to participate successfully in those contexts by harnessing relevant practices, discourses, and artifacts. Local, moment-to-moment interactions signal what constitutes learning, participating, and communicating at those times. While conceiving of learning as situated meaning making reflected in qualitatively different participation practices, this perspective emphasizes tool-mediated activity in learning. It also breaks down the conceptual barrier between the individual and the social.

The sociocultural perspective contends that learning in any context involves and even demands identity shifts. The sociocultural conception of identity highlights how identity is locally and interactionally constructed and altered in relation to specific social settings and actors (Hand, 2006; Holland, Lachiotte, Skinner, & Cain, 1998; Nasir & Saxe, 2003; Wenger, 1998). Here, identity is examined according

to the ways in which one is positioned, as well as how one positions himself or herself in the moment and over time across a variety of social practices. In line with research by Nasir and Hand (2008), in our work we are interested in young people's *practice-linked* identities, which are defined as identities that people appropriate, construct, and embrace, and which are linked to participation in particular social and cultural practices. The practice-linked identity one negotiates in relation to a practice is shaped by features of the practice that both enable and constrain the nature of the engagement, including its organization, norms, conventions, and structures. Our hybrid approach to learning and identity holds that when an individual feels that his or her identity is linked to settings, he or she will become more engaged in learning (Wortham, 2006). Therefore, it is important to examine how drawing from multiple funds of knowledge relates to youth identity development within and across social contexts.

Our conception of hybrid learning is also related to the notion of social ecology in that it posits learning to be a complex, reciprocal process dependent on constructive, culturally relevant interactions between learners and their social ecologies (Barron, 2004). A social ecology can be defined as a set of interacting contexts in students' lives that mediate their engagement and learning. Each of these contexts is comprised of a unique configuration of activities, material resources, relationships, and interactions (Barron, 2006). The social ecological approach positions the learner in meanings, practices, structures, and institutions organized by the interrelated contexts of their lives, including peer relations, family, and school (Barron, 2006; Bronfenbrenner, 1979). It also guides our understanding of the role of digital media in young people's lives by focusing not on the learning potential of individual media, but instead on how young people's object-oriented actions, individually and collectively, intersect with key institutions in their lives (Ito et al., 2013). In our approach, then, we are not focusing on the learning potential of digital technologies and media in isolation from their social contexts and object-oriented activities, but rather on how socially-shared, technology-mediated activities create opportunities for hybrid learning in which young people's life-worlds intersect with the educational objectives of their schools.

CASE EXAMPLES

Next, we will introduce two empirical cases from Finnish education that represent efforts to create hybrid learning opportunities in which students' everyday (i.e., informal) worlds are intertwined with their formal education. In our analysis, we will demonstrate how attributes of formality and informality intersect in the learning activities of each case and consider their implications for students' engagement and learning. We will end our analysis by considering the defining features of the pedagogical contexts that can explain the identified social practices, including the conditions for hybrid learning. Empirical research on these cases has also been reported in other publications (e.g., Kumpulainen, Mikkola, & Jaatinen, 2014;

Rajala, Hilppö, Lipponen, & Kumpulainen, 2013; Rajala, Mikkola, Tornberg, & Kumpulainen, 2011).

Our analysis of the case examples was guided by the following research questions:

1. What is the nature of student engagement and learning in each case?
2. How do attributes of formality and informality intersect in each case?
3. What are the defining features of each case in terms of their pedagogical design?

Case 1: Promoting Collaborative Creativity by Integrating Technology with Literacy and Arts Education

Our first case involves a year-long school musical project in a Finnish elementary school community of 240 students (grade levels 1–6) and 16 teachers in the Helsinki district. During the last seven years, the elementary school community has developed its pedagogical culture by integrating arts and educational technology in the curriculum and pedagogical practices. Educational technology and media are regarded as pivotal instruments in supporting creative and collaborative learning among members of the school community, and promoting students' engagement and agency in learning. Within this ethos, the students and teachers at the elementary school participate in various cross-curricular collaborative projects every year as part of their schoolwork. A collaboratively produced timeline of the school's ongoing activities provides a collective landscape for the school community to follow its plan of action, including responsibilities and deadlines that have been mutually agreed upon.

In fall 2010, all 240 students participated in a communal musical production; during a period of one year, the students worked together with their teachers, collaboratively producing a number of poems, short movies, audiovisual effects, animations, stories, school musical scripts, and a composition of musical melodies using various technological tools and devices, such as cameras, Smart Boards, music storage devices, lights, and the school's PA system. The outcome of the students' work, the fantasy school musical "Magic Forest Musical," was performed on the anniversary of the school's founding, in May 2011. The event was attended by parents, grandparents, ex-students, and local community members. The musical was also video-recorded and digitalized for wider distribution.

The communal musical production was integrated into the curriculum of the school and both complemented and enriched the achievement of the national core curriculum that every school is obliged to follow in Finland. The musical production is a good example of the creation of a local, school-based curriculum and annual plans that are collaboratively designed by the whole school community.

As part of the year-long musical production, 21 fifth- and sixth-grade students (ages 11 and 12) took part in writing the script for the school musical. The students worked in 10 small, self-selected teams of two or three students, with each team writing one part of the script. In addition, the students could participate in the online

work of any other team if they wished to. To enable the students' collaborative creation of the script inside and outside of school, they were given small, one-to-one computers (i.e., netbooks) set up with a 24-hour wireless Internet connection and personalized user accounts. The laptops were equipped with the VisciPad collaborative writing tool, which includes a chat channel. Although the chat channel provided a support function for the student teams and was completely optional, the scripts had to be completed within the 3-month time period for the musical project to proceed. As a final result of the project, the students produced 14 different scripts that became an essential part of the musical production.

The students' interactions during their collaborative script writing provided evidence of deep and sustained engagement in collaborative writing processes for the school musical across space and time. The students were instructed to use the VisciPad writing tool outside of the two weekly 1-hour sessions allocated for collaborating on writing the musical at school. On average, nearly 70% of the students' script-editing events, and 43% of their chat messages, fell outside of scheduled lessons. Similarly, 14% of all script-editing events, and 6% of chat messages, were sent during the weekend. Taken together, these hybrid learning practices appear to depart from traditional learning activities by allowing students to navigate across different time zones, spaces, and places with diverse tools situated in their formal and informal lives.

The excerpt below (see Table 1) illustrates the nature of students' chat interactions during their collaborative creative writing activities. The excerpt demonstrates students' playful and creative use of language in a context in which their formal and informal lives exist side by side. The students also engaged in thoughtful discussions about the nature and progress of their joint script for the school musical: they evaluated their collective work, gave supportive feedback to each other, and asked for help in creating text and using the technology. These social interactions are important elements of productive, collaborative work and learning (Dillenbourg, 1999; Koschmann, 1996).

Students' Perspectives on Their Learning Activity

According to the students, the possibility of interacting with friends through the chat channel was considered the greatest advantage of using laptops and VisciPad during their collaborative creative writing. Many students also mentioned appreciating the possibility of working flexibly inside and outside of school settings—regardless of time and place. Through increased mobility and ubiquitous wireless connectivity, the students were able to write the script at school and during their spare time, which gave them more freedom in designing their own learning places and work pace. The students could also flexibily record their creative ideas as they emerged in different situations and at different times. The collaborative writing tool gave the students opportunities to suggest, invent, and propose ideas for collective reflection, as well as encouraging them to analyze their writing processes and explore the past, present,

Table 1. Nature of the students' chat interaction

March 4 1: Minna: Mooi (11:46) 2: Aino: Hahaa … korjasin yhden kirjoitusvirheen!!.D (16:18) 3: Outi: just jo, no ei se haittaa (20:03) 4: Outi: siis joo (20:03) 5: Satu: moi löysin tänne joten jätin teksti jäljen:)) (22:11) *March 5* 6: Outi: :) (11:37) 7: Elli: moi (12:50) *March 6* 8: Tanja: tarviin ideoita! (12:14) *March 7* 9: Satu: huomenta;) Miten täl kooneella pystyy tekee sydämmen? (07:43) 10: Elli: öööö Emt (09:23) *March 11* 11: Elli: Biisi levyltä (12:19) *March 12* 12: Aino: Moi sannanen ja kaikki muut! Täällä on pikkasen yksinäistä. haloo!! (12:55) *March 15* 13: Suski: moi sannaaaaaaa … hyvin näyttää edistyvän=) (19:31) *March 16* 14: Satu: kivalta vaikuttaa (17:01) *March 21* 15: Elli: Dankke (09:18) *April 4* 16: Suski: hellou kivalt näyttäääää!!! kuka opettaa noille tyypeille ne kaikki temput??? vai onko ne nyt jo niin taitavii et osaa ne kaikki??????? (19:24) *April 11* 17: Outi: Enni PIKE! Opettaa niille noi kaikki ja mä pääsen kans niitten liikkatunnille (09:20) 18: Outi: No moi (12:31)	*March 4* 1: Minna: Hiii (11:46) 2: Aino: Hahaa … I corrected a spelling mistake!!.D (16:18) 3: Outi: ye, well that's okay 4: Outi: I mean yes (20:03) 5: Satu: hi I found my way here so I left a footprint:)) (22:11) *March 5* 6: Outi: :) (11:37) 7: Elli: hi (12:50) *March 6* 8: Tanja: I need ideas! (12:14) *March 7* 9: Satu: morning;) How can I make a heart with this computer? (07:43) 10: Elli: öööö dunno (09:23) *March 11* 11: Elli: A piece of music from a record (12:19) *March 12* 12: Aino: Hi Sannanen and everyone else! It is a bit lonely here. haloo!! (12:55) *March 15* 13: Suski: hi sannaaaaa … it seems that this is progressing well=) (19:31) *March 16* 14: Satu: looks good (17:01) *March 21* 15: Elli: Thanks (09:18) *April 4* 16: Suski: hellou, looks good!!! who teaches all the tricks to those guys??? or are they now so clever that they already know everything??????? (19:24) *April 11* 17: Outi: Enni PIKE! Teaches them all those things and I can also join them for their PE lesson (09:20) 18: Outi: Well hi! (12:31)

and future of their creative processes, as demonstrated by this student's response: "*I think VisciPad was useful since I could chat with my work partner at the same time. You could also see what each one of us had written. It was great to have laptops at home, since you could immediately write down a good idea when it came to mind.*"

When asked about how they used their personal laptops and VisciPads outside the classroom, the students reported using them for a range of purposes, including but not limited to the writing of the school musical itself. The students' technology-mediated practices at home included watching YouTube, listening to music, playing games, chatting, "Facebooking", and reading email. Moreover, the students reported using the technical tools for preparing for their school exams and collaborating with their friends in different virtual communities. These data reflect the multimodal life-worlds of young people. Here, schoolwork and related learning practices have become a flexible and integral part of the students' ecologies of living and learning.

Students also reported having been simultaneously engaged in other activities, both inside and outside of school, while writing the script for the musical. Common activities included listening to music, "Facebooking", watching YouTube, chatting, playing games, browsing and searching for information on the Internet, and reading email. In other words, the students engaged in multitasking that entailed the use of various artifacts embedded in the students' formal and informal lives.

When asked about the conditions and settings in which they felt the most creative, the majority of the students reported getting the best ideas for the script both at home and at school. Some students stressed the importance of the social and collaborative nature of creative work, while others reported getting the best ideas for the script when they were alone: "*when it was quiet, or when we were doing 'something else' other than writing the musical script.*" The following extract illustrates the collaborative nature of the students' creative learning activities: "*Some ideas I got after school at my friend's house. And then I shared them at school the next day. Also, some ideas came after someone else got an idea.*" Apparently, the construction of creative ideas is fostered in learning settings in which students are given enough time, flexibility, and space to work with their ideas and even go beyond what is expected of them.

Case 2: Developing Students' Sense of Citizenship through Technology-Mediated Inquiry

Our second case draws on a year-long social studies elective course in the Etelä-Tapiola upper secondary school in Espoo during the 2010–2011 school year. The school places special emphasis on issues related to sustainable development and social and civic matters. The school's students have a wide variety of elective, cross-curricular collaborative courses to choose from every year.

The specific goal of the *Bicycles on the Move!* course was to support the development of upper secondary school students' (aged 16 to 18) sense of

citizenship, including cooperation skills and knowledge concerning their rights and responsibilities as members of society. Course activities included student collaboration with representatives of various institutions and communities in order to influence Espoo's decision-making policies in regards to bicycling. The course teachers provided numerous ways for students to complete the project assignment, and they could do so either alone or in pairs. However, each student was required to document the school neighborhood by using a camera to photograph obstacles for bicycling and provide solutions that facilitated bicycling. A technological learning environment called *Linkki,* which features interactive maps of local neighborhoods with marked bicycle routes, was also used in the course. The students could use Linkki to share their observations and opinions with each other, as well as with their teachers, other experts and community members. Other digital resources, such as YouTube, allowed the students to identify and share various information about bicycling.

The *Bicycles on the Move!* course transferred learning from the school to an authentic, external environment that connected with students' own interests, as illustrated by the following excerpt from a teacher's interview: "*Well, it started when Heureka was looking for cooperation in this Bicycles On the move! to explore these environments—whether it's a cultural path or climate … something that would happen in the immediate surroundings. And then we just ended up with it, and Mikael, he was already enthusiastic about cycling and accessibility. So two years ago we went for bicycling; that is, it's our thing.*"

The teachers found it important that students learned that they could make a difference in matters that concerned them, and that they knew what tools were available to help them reach their goals. The teachers also emphasized the importance of students' everyday observations of society and their own lives as a means for developing their sense of citizenship. For example, the teachers arranged a meeting with a manager of a large shopping center nearby to discuss the ways in which bicyclists are taken into account when making traffic arrangements. In order to prepare for this meeting, the teachers encouraged the students to become "cycling experts of the Tapiola area."

The Bicycles on the Move! course enabled students and teachers to make connections across a wide range of contexts in their lives. These contexts were discursively evoked and juxtaposed in classroom dialogue. Here, the students' and teachers' experiences and knowledge of bicycling issues were actively harnessed for joint inquiry, reflection, and civic engagement. For example, the teachers shared their everyday observations on the number of male and female bicyclists, as well as their concern for those who choose not to wear helmets. Moreover, the teachers recounted their discussions with local politicians and the actions they had personally taken in order to influence local decision making. In turn, the students shared their own experiences with bicycling and the various community events in which they had participated. The students had selected these events from a list provided by their teachers, which included bicycling seminars nearby and an open lecture arranged by

the school. The students also took initiatives in recounting their bicycling experiences with the classroom community.

Dialogue was one of the major resources for learning in the course. The teachers provided models for critical thinking, and the students were expected to take part in exploratory interactions. Doing so also promoted and strengthened social relations among the students, as demonstrated in this excerpt: "*You can get to know other people better when you don't sit in the classroom where you cannot see what's behind your back. Here, you see the others and you can talk with them. The conversation takes place with everyone, and the teachers are not necessarily always in a key position. … In normal lessons, there is not so much interaction between the students.*"

In the next excerpt from a classroom discussion, reference is made to both the students' and teachers' observations of a motorway intersection near the school.

Teacher 1: *Have you had any insight so far on what you could do? [a long pause] Have you even thought about this?*

Student: *I have thought about it umm about Ring I, it's being built, there are big constructions going on. Maybe something about that now.*

Teacher 1: *[interrupts] Do you mean there at Leppävaara?*

Student: *Yea yea, that's right. There is the motorway intersection and then um the tunnel. If that could be something?*

Teacher 1: *Yes yes, what about cycling or that?*

Student: *Yes exactly, public transportation or I mean pedestrian and bicycle traffic solutions.*

Teacher 1: *Yeah, yeah, that would be good to look at and the plans around it.*

Teacher 2: *Really brilliant idea. I already looked into it last summer and I have already sent some emails about it but it doesn't really mean that nothing should be done about it.*

In addition, the students were given opportunities to observe and participate in social influencing. For example, one of the teachers drafted a 15-page statement concerning bicycling conditions in Tapiola, in an area where the city was planning a metro line. The statement was handed over to the city of Espoo's planning committee in fall 2010. Although the statement was not a joint group project, students were given an opportunity to comment on the text; in this respect, its potential nature as a good example of social influencing should not go unnoticed.

Taken together, the underlying intention of the activities and discussions during the course was to support students in learning how to engage in local decision

making. For instance, the pictures taken by students were used to take a stance in a current political debate about the route for a large street construction project in the Tapiola area. As there was at that time no plan for the route, the teachers stated that the authorities would be eager to listen to the students' suggestions and opinions. As another example, the TV channel *Euronews* came to the school to observe and interview the students for its news segment on bicycling. The educational significance of this event is evident in one teacher's account of the value of the course: "*there was this influential thing about it, not a school subject where you learn something that is written in a book, but it was connected with society directly.*"

Traditionally, in a classroom context, the dominant resources for student learning are textbooks and teacher lectures, as highlighted in the following student's statement: "*We are in a classroom and then use the textbook and make notes, and the pace is quite fast. There is always the one book per course. … In chemistry, we may do some experiments, but mostly you sit in the classroom, write and listen.*" Instead of textbooks, the *Bicycles on the Move!* course relied on students' and teachers' own experiences and observations, up-to-date political issues, and international discussions of bicycling. The multi-voiced interaction promoted critical awareness of the intentions behind the knowledge sources and fostered the students' own voices: "*Maybe you get insights. You can get yourself to think about things. They [the presenters in the seminar] brought in their opinions, but of course also facts. … I think that the idea was that we go there to listen and then we think about it ourselves as well. In a way, we got into this project better when we went there to listen. For example, I don't know so much about cycling, about the facts and such. So it was good to listen to many kinds of thoughts. … I think that when you read a textbook, the information is there, it's a fact, you don't question it. But when somebody else says it, when you attend some events, there can be something, and you start to explore it, and then you get more knowledge.*"

Furthermore, much emphasis was placed on the students' own actions and involvement, and teachers encouraged the students to be more active, as demonstrated by the following quote: "*This demands a contribution on your part. We can't make any progress during the lessons if you don't do something in your free time, if you don't produce any material … in May we'll be wondering what we could have done.*"

Technological mediation provided another important resource for the students' learning activities. A vast majority of course activities relied on the everyday use of mobile technology of the students. Moreover, both the discussion forum and the interactive Linkki map were valuable resources that supported the implementation of the course. Social media further enriched teaching and learning in the course. Last, but certainly not least, the huge personal effort that the teachers put into the course did not go unnoticed by the students, who reported the enthusiasm of the teachers to be personally motivating, as was their persistence in "pushing" them forward to accomplish their goals.

Synthesis: Contrastive Analysis of the Defining Features of the Pedagogical Design of the Case Examples

We now turn to our analysis of the defining features of the two case examples in terms of their pedagogical design. Our contrastive analysis of the cases rested on eight attributes: Object, Subjects, Location, Instruments, Community, Codes of Conduct, Roles and Relationships, and Assessment and Accreditation. We suggest that these features are potentially useful in explaining hybrid learning and, more generally, in analyzing and understanding the interplay and balance between formality and informality in learning activities. In our analyses, we drew especially on Engeström's (1991) ideas on expansive learning, as well as on Colley, Hodkinson, and Malcom's (2003) conceptualization of learning as formal and informal attributes (see Table 2).

As Table 2 shows, the cases we have introduced and discussed in this chapter share many commonalities (regarding their objects, subjects, location, instruments, community, code of conduct, roles and relationships, and assessment and accreditation) but also some differences in terms of their pedagogical design. In both cases, the *object* of activity was geared toward hybrid learning in the context of socially shared creative (Case 1) and inquiry-oriented (Case 2) activity, as well as in the context of cross-curricular content (Case 1) and the transformative application of cross-curricular content (Case 2) both inside and outside of school. Characteristic to *both* cases is that funds of knowledge framed by everyday literacies were brought into formal education and learning in ways that expanded learning practices typically valued in both school and in the everyday world. Here, everyday resources, such as youth media practices, were bridged with disciplinary learning to construct new texts and new literacy practices: ones which merge the different aspects of knowledge and ways of knowing offered in a variety of different spaces youth inhabit (Moje et al., 2004; Moll & González, 1994; Morrell, 2002; Seiler, 2001). The object and context of learning were transformed as students, teachers, and other participants engaged in collective social activities by sharing and negotiating.

Likewise, in both cases, the *subjects* involved teams of students and teachers, as well as experts and community members. Collaboration and peer-to-peer working was specific to Case 1. Also in Case 1, the local community was positioned in the role of an audience for creative work in the school musical. The distributed nature of expertise to support and scaffold students' engagement and learning was extended in Case 2 by the involvement of city officials and bicyclists from local and global contexts. The facilitating role of the teachers also became more visible in Case 2.

The *location* of the activities of both case examples was distributed across space and time, including the school, home, and local and global communities. Also typical to both cases was that the instruments for engagement and learning were shared, examined, and negotiated in socially shared and technology-mediated activities.

In Case 1, the *instruments* for mediated practice included the school curriculum, students' funds of knowledge and literacies, and teachers' funds of knowledge and literacies; whereas in Case 2, they also included community funds of

Table 2. Defining features of the pedagogical design of the cases

	Case 1: Promoting collaborative creativity by integrating technology with literacy and arts education	*Case 2: Developing students' sense of citizenship through technology*
Object What is the object of activity?	school curriculum, *students' life-worlds*: socially shared *creative activity, co-creation,* cross-curricular content	school curriculum, *expert communities,* students' life-worlds: socially shared *inquiry,* discovery and co-creation, *transformative application* of cross-curricular content
Subjects Who is taking part in social activity?	*teams of students,* teams of teachers, *whole school community,* local communit	*students, teams of students, teams of teachers,* local community, *expert communities*
Location How is time and space organized?	*distributed across space and time:* school, home, local community	distributed across space and time: school, home, *local and global communities*
Instruments Which instruments mediate social activity?	school curriculum, *students' funds of knowledge and literacies,* teachers' funds of knowledge and literacies, *collaborative creativity, peer-to-peer interaction,* digital media, ubiquitous technology	school curriculum, students' funds of knowledge and literacies, teachers' funds of knowledge and literacies, *community funds of knowledge, inquiry,* digital technology
Community Which communities are involved in social activity?	a connected network: *school community, home,* local community	a connected network: *classroom community,* home, *local community, expert communities*
Code of conduct Who has responsibility for constructing and monitoring rules for social action? What are the dominant rules for social activity?	collectively constructed and monitored various participation opportunities and ways to contribute	collectively constructed and monitored various participation opportunities and ways to contribute
Roles and relationships How are roles and relationships defined?	individual and *collective agency and accountability*	*individual* and collective *agency and accountability*
Assessment and accreditation What is the nature of assessment?	ongoing, distributed across communities of the connected network: authentic	ongoing, distributed across communities of the connected network: authentic

knowledge contributed by experts. The interaction of these different instruments gave rise to hybrid spaces, including the negotiation and examination of vertical and horizontal knowledge and knowing. In both cases, building on the students' observations, experiences, and funds of knowledge, teachers and experts were able to support the students in thinking with, rather than about, their experiences and views (Kumpulainen, Vasama, & Kangassalo, 2003). In addition, multiple cultural resources were used in collective meaning making. However, rather than treating these as authoritative voices (Bakhtin, 1981; Scott, Mortimer, & Aguiar, 2006), the classroom communities examined them critically against their own personal experiences and observations. Yet, as our cases demonstrate, sensitive and professional support is also required to orchestrate the dialogue and social activities toward educational goals.

Altogether, the *communities* and their expertise involved in the cases created a connected network to support and further collective inquiry and learning. As the cases demonstrate, knowledge and knowing were not only associated with teachers, outside experts, or the curriculum, but with *everyone* who participated. In other words, the students were seen by themselves and by others as knowledgeable and committed participants whose practice-linked identities were variable, multivocal, and interactive (Holland et al., 1998; Wenger, McDermott, & Snyder, 2002). Here, engagement in the activities was not only tied to expertise and knowledge, but also to young people's interests (Hofer, 2010). Students' interests were recognized, valued, and harnessed to advance sustained engagement in co-examination and the creation of meaning and knowledge (Crowley & Jacobs, 2002).

Also common to both cases was that the *codes of conduct* for social activity were socially negotiated and agreed upon. The rules for social activity in both cases can be characterized by various participation opportunities and ways to contribute. Moreover, the establishment of joint reference for collective action was systematically and explicitly orchestrated. For example, in Case 1, the construction of rules for collective action was achieved by all members of the school community in the joint creation of a year-long timeline visible to everyone for ongoing reference. We could see how the students' communication of disciplinary knowledge became an authoritative practice, and the justification and sharing of findings became a matter of accountability. Consequently, hybrid learning opportunities broadened traditional forms of learner agency and accountability by expanding possibilities for engagement and bringing in new audiences with whom students could collaborate.

Distinct to the nature of *roles and relationships* in both cases was that they emphasized individual and collective agency and accountability. Here, engagement and learning were supported by scaffolding, peer-to-peer interaction, and participation in authentic communities of practice, both online and offline. The social construction of hybrid learning opportunities demonstrated by the cases provided students with multiple and diverse positions of authority and accountability. Here, the students were observed to build and connect to a network of different community members; they were also held accountable for producing thoughtful and justified opinions and

arguments that would contribute to shared problem solving and learning within and across communities of practice. The students' accountability to peers, teachers, and experts representing disciplinary communities was also reflected in the ways in which meanings were negotiated and types of knowledge and knowing prioritized (Holland et al., 1998). We also identified a type of hybrid learning that involved students taking a transformative stance to their learning activity. At the same time, the students also took part in co-constructing cultural practices entailing what it means to make meaning, participate, and learn at school, which in turn assisted in the building of their identities. Moreover, they were also working toward the transformation of community life via the production and sharing of their academic learning with local communities. All of these are important elements of and for transformative practice, promoting not only school learning but civic engagement as well (Stetsenko, 2008).

In both cases, *assessment and accreditation* of learning was ongoing, authentic, and distributed over the connected communities. Here, evaluation and recognition of the processes and outcomes of learning were expanded from the traditionally teacher-controlled and structured system of instruction and assessment to various communities of practice. For example, in Case 2, the transformative nature of the students' inquiry work was communicated even via the local news media, resulting in critical communal examination. The whole network of communities and participants were both the creators and evaluators of joint activity and its outcomes.

The Interplay and Balance between Formality and Informality in the Case Examples

We can identify at least three forms of hybrid learning in the case examples. The first form of hybrid learning, *a bridging space*, illuminates how students' informal funds of knowledge entailing various discourses, literacies, and media practices—which are often marginalized in school settings—were bridged with formal education. This form of hybrid learning is specifically demonstrated in Case 1, which created a space wherein students' informal and socio-emotional engagement was mediated by their chat interactions during peer-led collaborative creative writing for the school musical. Such hybrid learning can be regarded as important because it provides a space for typically marginalized voices, with the potential to increase academic engagement and accelerate learning (e.g., Gutiérrez et al., 1999; Heath, 1983; Hudicourt-Barnes, 2003; Lee & Fradd, 1998; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001).

The cases also illustrated a second form of hybrid learning: *a navigational space* that involved students crossing through and succeeding in different communities of practice while simultaneously engaging in their academic learning activities. This has been a dominant perspective in studies that have examined the crossing of social and interactional disciplinary boundaries as students encounter the discourses specific to those disciplines (Hicks, 1995/1996; Hinchman & Zalewski, 1996; Lemke,

1990; Luke, 2001; Moje et al., 2004). The navigational nature of hybrid learning is exemplified by Case 2, in which the students, as part of their inquiry activities, interacted with several different communities of practice. These communities included city officials as well as local and global communities of professional bicyclists and citizens. Becoming involved in a range of cultural communities as part of their academic work will likely expand students' cultural toolkit in ways which will help them to engage accountably in different contexts as they develop legitimate and increasingly centered means of participation and communication (Vygotsky 1962, 1978; Wells, 1999; Wenger, 1998). Moreover, navigating and critically examining various funds of knowledge of different communities will likely enrich and advance students' meaning making and learning skills.

The third and last form of hybrid learning can be defined as *a space of cultural, social, and epistemological change* in which different and sometimes competing types of knowledge and discourse are brought into the conversation to challenge and reshape both academic learning practices and the funds of knowledge accessible to youths in their everyday lives (e.g., Barton, 2001; Hammond, 2001; Lee, 1993; Moje et al., 2004; Moll & González, 1994; Morrell, 2002; Seiler, 2001). We can detect instances of this form of hybrid learning in both of the case examples. In Case 1, the whole school community was transformed by their joint engagement in the musical production, as evidenced by the construction of new discourses, literacy practices, conceptualizations of curriculum implementation, and modes of collaboration, both within the school and within the local community. In Case 2, the inquiry activity of the school not only impacted the students and teachers but the local community as well, thus making a difference at many different levels. As a result, the students learned new ways of contributing to the community, whereas the city officials, politicians, and local community in general gained new knowledge about bicycling conditions in Espoo.

DISCUSSION

In this chapter, we have introduced a novel conceptual framework for addressing ongoing research and debates on the intersection between academic and everyday learning and how this should be transformatively bridged as part of formal education. In our work, we are specifically interested in a notion of hybrid learning that can be achieved when diverse *funds of knowledge*—defined as a set of discourses, literacies, and social practices embedded in young people's social ecologies—meaningfully intersect as part of educational practice. We contend that focusing on the attributes of formality and informality in social activity is a useful approach for developing a more comprehensive understanding of when, how, and why hybrid learning is constructed, as well as its implications for students' educational engagement and learning.

The complexity of contemporary society calls for new kinds of educational opportunities to serve the multiplicity of needs of millennial learners. Designing

learning opportunities that respond to students' holistic life-worlds and reconfigure spaces and places of learning is critically important in contemporary learning, where an increasing number of students feel disengaged and disconnected from formal education. Moreover, living and learning in a digitalized and globalized society requires skills and competencies that cannot be adequately addressed by narrow and product-oriented views of education and schooling. Twenty-first-century learning requirements, such as creativity, critical thinking and problem solving, collaboration and communication, and new literacy and media skills are challenging or even impossible to promote in an educational environment that is restricted to a specific space and time and is purely teacher-led and controlled (Kumpulainen et al., 2010; Lemke, 2004; Trilling & Fadel, 2009).

Research among youth has revealed that, contrary to the view of the Net Generation as dissatisfied individuals who do not value school, there is evidence that many young people see school as a valuable learning environment (e.g., Bennett, Maton, & Kervin, 2008). Yet, it is the nature of school learning that is often impersonal, narrow, and authoritative, that makes it easily irrelevant and meaningless for many young people. It is unwise to assume that the interests, motivations, or affinities of all young people will be automatically enhanced by the simple inclusion of digital media technologies in educational contexts. In fact, without a meaningful pedagogical agenda, students may react negatively to the use of technologies and media in formal education; they may perceive such attempts as an invasion of their free-time domains (Moje & Hinchman, 2004; Sharples, 2006; Ziehe, 2000). Indeed, a number of researchers have warned against attempting to motivate and engage students by simply introducing publicly trendy forms of media technology into educational processes and practices. Students are unlikely to automatically use and be motivated by the use of digital technologies, social media, and gaming for educational purposes if such technologies are not meaningfully integrated into learning practices and pedagogies that support authentic and transformative engagement and learning (Collins & Halverson, 2009; Jonassen, Howland, Marra, & Crismond, 2008; Kemker, Barron, & Hermes, 2007; Kumpulainen et al., 2014).

Educational learning opportunities that extend across space and time—that are responsive to students' social ecologies and diverse funds of knowledge—require pedagogical innovation and transformation. This in turn requires social, cultural, and technological support that will enable learners to link, integrate, and translate their formal and informal funds of knowledge into educational opportunities (Ito et al., 2013). Hybrid learning addresses the gap between in-school and out-of-school learning. In doing so, it harnesses contemporary technologies and digital media to link home, school, community, and peer funds of knowledge, drawing from the capacities of diverse communities. It recognizes learning as an ongoing process, connected to a diverse and evolving ecosystem of learning resources, institutions, communities, and outcomes in order to advance the cause of educational and social equity (Freire, 1970).

Toward Hybrid Learning in Formal Education

Hybrid learning has implications for schools and education in general, including the design of learning environments. It provides teachers with a more holistic way of thinking about their students, directing attention to epistemic and ontological dimensions of learning. Here, individual growth is tied to collective goals and community development. In hybrid learning, collective and individual outcomes are intrinsically co-related, and learning outcomes in general are seen as greater than individual accomplishment. In many ways, the hybrid learning approach is part of a longstanding tradition in progressive education that has stressed the importance of civic engagement, the interconnection of schools with the wider world, and the value of hands-on and social learning (Dewey, 1916). Modern technologies offer us the ability to pursue these progressive goals in new ways through the purposeful integration of tools for social connection, knowledge co-creation, and the interconnection of the classroom, community, and home. From this perspective, the role and position of the school in the digital age needs to be seen not as an opposition to youth cultures nor as *digital enrichment* of traditional schooling, but rather as an important part of a network of learning contexts that optimally create a supportive ecosystem for engagement and learning for a diverse array of students.

It is important to acknowledge that hybrid learning is a developmental achievement that can only emerge through sustained collective effort within the school community and via persistent interaction with local and global communities: our case examples provide clear evidence of this. Without a pedagogical culture within which to transform traditional learning practices, digital media and the funds of knowledge of contemporary youth would likely represent merely an additional layer to schooling, which in turn could increase the likelihood of counter-productive consequences. Thus, it is not just a matter of implementing and putting into use alternative pedagogical ideas and technologies; rather, in many cases, it is also a matter of simultaneously transforming existing social practices. Co-evolution of the social and technological infrastructures of education should be the starting point for expanded and hybrid learning opportunities (Kumpulainen et al., 2014). Hybrid learning practices should be locally improvised in conjunction with mediation via socio-historically developed genres, technology-based instruments, and educational practices (Prior, 2005). Hybrid learning also involves connecting learning across settings and communities over time. For instance, in order to connect learning and teaching to expert communities outside of school, teachers and school administrators should build partnerships and networks. Building networks and partnerships also requires new competencies from teachers, such as being able to engage in multi-professional collaboration (Kumpulainen et al., 2010).

Hybrid learning calls for educational learning activities that are authentic and current, and which address complex problems. As our case examples demonstrate, these learning activities have the potential to expand forms of accountability by expanding the requirements for engagement and by bringing in new audiences

with whom students can pose questions and share and discuss their observations, opinions, and reflections; in doing so, they will also co-develop new knowledge and understandings. In these situations, students are likely to see the meaningfulness and applicability of their learning within and beyond the context of school. In essence, the culture of learning as mediated by a hybrid approach leaves ample room for creativity, re-negotiation, and surprises.

ACKNOWLEDGEMENTS

The production of this chapter was supported by the *Learning in the 21st Century* research project funded by the Norwegian Research Council's PRAKUT program. We would like to thank Lars Vavik and his research team for their valuable comments in the preparation of this chapter. We would also like to acknowledge the work of Antti Rajala in the data collection and analysis for Case 2.

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LISBETH M. BREVIK

3. THE GAMING OUTLIERS

Does Out-of-School Gaming Improve Boys' Reading Skills in English as a Second Language?

INTRODUCTION

Elisabeth Bernhardt (2011) has said that "readers who struggle in their first language will probably also struggle in their second" (p. 38). Her *compensatory model of second-language reading* suggests that 20% of how we read in a second language (L2) relates to how we read in our first language (L1). In addition, she argued that approximately 30% can be explained by how well we know vocabulary and grammar in the L2. Although the good news about this model is that 50% of the L2 reading process seems to be accounted for, the bad news is that *only* 50% is accounted for (Bernhardt, 2011, p. 33). The rest of our L2 reading competences are referred to as so-called "unexplained variance," which relate to variables like engagement, interest, and motivation, as well as the readers' content and domain knowledge, and their use of comprehension strategies.

Bernhardt (2011) based her model on only a handful of studies (Bernhardt & Kamil, 1995; Bossers, 1991; Brisbois, 1995; Carrell, 1991; Lee & Schallert, 1997), yet it is consistently cited in the research as accurate. I therefore wanted to bring the Bernhardt model to test. The model is relevant for second language reading in many ways; for example, it included different readers (children, adolescents, and adults) and different languages (Spanish, French, English, Turkish, and Dutch). Still, the notion that a poor reader in the L1 will also be a poor reader in the L2 needed to be challenged, particularly because the topic has remained unexplored.

The Context of the Study

First, I conducted a nation-wide large-scale study of 10,331 students in upper secondary school with two colleagues. In the study, we compared their reading in Norwegian as the L1 and English as the L2 (Brevik, Olsen, & Hellekjær, under review). This was the first time reading across these languages was investigated at this level. Using test results from two national reading tests, we identified the poorest readers in the L1 (n = 2,123) to be those who scored beneath the pre-set intervention benchmark (Norwegian Directorate for Education and Training [UDIR], 2010a, 2010b). We found that, among these poorest readers in the L1, only 56% were poor

E. Elstad (Ed.), Educational Technology and Polycontextual Bridging, 39–61.
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readers in the L2 as well (n = 1,192). In fact, 22% of them (n = 463) read markedly better in the L2 than in their L1. This was a most unexpected finding. These 16-year-olds, whom we labelled "Outliers," were among the poorest readers in their L1 and at the same time among the most proficient readers in the L2, answering 60% or more tasks correctly in the L2 test. Among these Outliers, boys outnumbered girls and students in vocational studies (VS) outnumbered students in general studies (GS); specifically, the Outliers included boys in VS (40%), boys in GS (26%), girls in VS (18%), and girls in GS (16%).

These Outliers challenged Bernhardt's (2011) notion that a poor reader in one language is most likely a poor reader in another, and also the dichotomy of identifying students as either good or poor readers (e.g., Alderson, 2000; Bråten, Amundsen, & Samuelstuen, 2010; Grabe, 2009). Moreover, and in line with Koda (2007), identifying the Outliers suggested that reading in an L2 was a complex phenomenon. With regard to L2 reading in school, one of the questions raised by our prior study (Brevik et al., under review) was how and why this otherwise underperforming group had developed high levels of reading proficiency in English. Based on these unexpected aspects of reading, the present study examines adolescents with the Outlier profile in further detail, aiming to identify what characterises them as good readers of English as an L2.

What Do We Know about Adolescent Readers?

Adolescents are at a stage in life when they are undergoing changes in cognitive development and social relationships, shifting school environments, and educational expectations (Alexander & Fox, 2011; Grabe, 2009). They are often characterised by diminishing reading performance as they grow older, as indicated by test scores (Kamil, Afflerbach, Pearson, & Moje, 2011), which might explain the current research focus on these adolescents as struggling readers and endangered learners (e.g., Alexander & Fox, 2011; Alvermann, 2002).

Indeed, the problem of poor reading is important for adolescents, particularly since the Organisation for Economic Co-operation and Development (OECD) report *Education at a Glance* (2014) stated that, in some European countries, only 40% of students who entered upper secondary school (16–18 years) completed their education within the stipulated time (p. 60). Among the 26 participating countries with available data, 64% of students in vocational programmes and 76% of students in general programmes graduated within the stipulated time (p. 63). The question is to what extent poor reading proficiency contributes to this situation. In this respect there has been some concern about the underperformance of boys in reading compared to girls (Motiejunaite, Noorani, & Monseur, 2014; Topping, Samuels, & Paul, 2008). This concern is relevant for the present study, since boys were the majority among the Outliers, who both outnumbered and outperformed girls when reading in English.

For Norwegians, English is considered an essential language (Crystal, 2012), particularly following the increased out-of-school exposure and increased English language proficiency (Rindal, 2013). However, although conversational English is widespread and daily exposure common, many students do not develop an adequate level of academic English to pursue higher studies in English (Education First, 2015). The latter has also been Hellekjær's (2008, 2009, 2010) consistent argument over the last decade; in particular, Hellekjær has stated that Norwegian schools do not prepare students for academic English usage in higher education and work.

Which Variables Can Explain Good Reading in English L2?

Since there is no relationship between the Outliers' reading proficiency in the L1 and the L2, it is relevant to consider whether their English proficiency can be accounted for by variables in the unexplained variance in Bernhardt's (2011) model. These variables could include engagement, interest, and motivation, the readers' content and domain knowledge, or their use of comprehension strategies.

While L2 reading comprehension seems to be related to content and domain knowledge (e.g., Brantmeier, 2005; Pressley, 2000) as well as comprehension strategies (e.g., Brevik, 2014, 2015; Block, 1992; Grabe, 2009), the relationships between L2 reading and interest, engagement, and motivation seem more uncertain (e.g., Brantmeier, 2007; Brantmeier, Bishop, Yu, & Anderson, 2012; Verhoeven, 2011). However, as Garcia, Pearson, Taylor, Bauer, and Stahl (2011) argued, the use of comprehension strategies requires readers to socially and personally engage with texts. Student engagement may therefore be key. Similarly, Alexander and Fox (2011) argued that interest is important to enhance reading proficiency, which makes it relevant to consider what characterises the Outliers' English reading activities both in and out of school.

In a recent study where I observed English classrooms and interviewed the students afterwards (16- to 17-year-olds), I found that it was necessary for the students to see personal purposes for using comprehension strategies to enhance their reading comprehension in English (Brevik, 2015). According to the participating students in GS, they used such strategies because the teacher asked them to, while the vocational students used the strategies because these helped them understand texts in and out of school (Brevik, 2015). This study highlighted the notion that, while using comprehension strategies will not transform a poor reader into a good reader, helping adolescents to see the potential of using strategies as tools might develop their reading comprehension, thus contributing to their development as English readers.

In fact, another Norwegian study (Sletten, Strandbu, & Gilje, 2015) identified a link between students' in- and out-of-school activities. Based on a secondary analysis of a large-scale national survey among 4,160 students (13–16 years old), Sletten et al. (2015) found a positive link between online gaming and English grades. While

the students who played online games several times per week, and more than three hours each time, had lower grades in Norwegian and Math than non-gamers, they had higher grades in English (Sletten et al., 2015). A similar positive correlation between gaming and English proficiency was also found in a Swedish study (Sundqvist & Wikström, 2015) among 80 students (15–16 years old). The study found that gamers who played more than five hours per week used more complex English words in a national writing test than non-gamers.

While these two latter studies found that the majority of the gamers were boys, all three studies suggested a link between the students' personal purposes for using English out-of-school, and school activities and results (Brevik, 2015; Sletten et al., 2015; Sundqvist & Wikström, 2015). These findings make it relevant for the present study to consider whether out-of-school gaming might improve the reading skills in English L2 among the Outliers.

In- and Out-of-school Gaming in the Norwegian Context

For several decades, scholars have investigated how games can be used for educational purposes (e.g., Gee, 2007). In Norway, Schofield (2014, 2015) found that learning activities based on the students' knowledge and skills acquired through media practices in everyday life contributed to a deeper understanding of concepts, critical reflection, and meta-perspectives. Similarly, Silseth and Arnseth (2011) revealed that games can function as powerful learning tools, although students might not uncritically embrace such resources when enacted at school. In fact, Silseth (2012) stressed the role of the teacher in so-called game-based learning and showed that success relied on a skilled teacher who managed to frame the gaming activity in productive ways. Even though the students' competence in playing games from leisure practices could be relevantly used in educational practices, Silseth (2012) found that such competence was not necessarily enough to cultivate conceptual understanding of academic matter. For this purpose, the teacher had to strategically scaffold the gaming, and make the content that students engaged with during game play relevant for dealing with the topic under consideration.

The findings in these studies indicate that there is a link between in- and out-of-school media-practices on the one hand (Schofield, 2014, 2015; Silseth, 2012; Silseth & Arnseth, 2011), and between gaming and general English proficiency and writing skills on the other (Sletten et al., 2015; Sundqvist & Wikström, 2015). These findings raise the question of whether there was a link between gaming or other out-of-school activities and school performance for the Outliers, who were among the poorest readers in their L1 but among the most proficient readers in the L2.

The Scope of the Chapter

As indicated above, this chapter contributes to research on students in upper secondary school in order to understand why some read significantly better in English

as their L2 than in their L1, Norwegian. While a few studies have examined English reading in Norwegian upper secondary school (Brevik, 2014, 2015; Hellekjær, 2008; Hellekjær & Hopfenbeck, 2012), only one recent study has systematically compared reading in Norwegian and English (Brevik et al., under review). That study argued for the need to pay attention not only to how these students read in school, but also how the students' use of English out of school relates to their personal reading purposes. In the current study, I address this issue by asking: *Why do some upper secondary students (16- to 17-year-olds) read significantly better in English than in Norwegian?* More specifically, this study addresses this issue through two research questions:

1. What characterises these students' use of English in and out of school?
2. To what extent do these students provide explanations as to why they are better readers in English than in Norwegian?

THEORETICAL PERSPECTIVES

This study was informed by socio-cultural thinking on the importance of tools and social interaction in learning (e.g. Daniels, 2005, 2008; Vygotsky, 1981). Since learners are not passive receivers of information (Daniels, 2005; Derry, 2008; Duke, Pearson, Strachan, & Billman, 2011), they actively engage with the activities, making personal connections between the task and other topics within and beyond the classroom, potentially using English as an L2 in this engagement. Thus, building on the Vygotskian notion of the active, sense-making learner (Vygotsky, 1981), Claxton (2007) pointed out the importance of developing metacognitive awareness in learners to foster conscious and active learning. Transparency in the nature and purposes of using English in social interaction in and out of school would therefore seem a worthwhile aim. In line with Claxton's (2007) argument, Pearson (2011) held that connecting texts to students' lives is one way of achieving engagement. Building on their arguments, I suggest a need to include attention to the purposes of reading English in the lives of upper secondary students.

Reading Comprehension across the L1 and the L2

Reading comprehension, according to the RAND Reading Study Group (RAND, 2002), is "the process of simultaneously extracting and constructing meaning through interaction and involvement with written language" (p. 11). This process includes the *reader* who is doing the comprehending, the *text* that is to be comprehended, and the *activity* in which comprehension is a part, occurring within a sociocultural environment "that shapes and is shaped by the reader" (RAND, 2002, p. 11). Grabe (2009) argued that social factors "are multiplied for L2 readers who must sort through competing cultural and social influences emerging from both L1 and L2

contexts, as well as many competing influences in the dual-language mind of each individual L2 reader" (p. 152).

Koda (2007) explained that L2 reading involves two languages, and argued that reading in the L1 influences and changes the reading process in the L2. She therefore suggested that a primary focus within L2 reading research should be to develop a clearer understanding of how the two languages interact. However, she based these arguments on the assumption that the readers are already more proficient readers in the L1, while it is their L2 skills that are developing. This stands in contrast to the Outliers in the present study, where the situation is reversed. As such, I have chosen to build on Koda's (2007) notion that reading in an L2 is a complex phenomenon that needs to be studied in more detail. To investigate this idea, I decided to conduct a mixed methods study.

METHOD

This study combined data from two national reading tests in Year 11, one in Norwegian and one in English, with data from questionnaires and interviews. The aim was to understand why some upper secondary students (16- to 17-year-olds) read significantly better in English than in Norwegian, by identifying their reading profile across the two languages and asking them how they used the languages in and out of school.

National Reading Tests

When students enter upper secondary school (Year 11), they can participate in national reading tests in Norwegian L1 and English L2. These tests have been conducted since 2010. In 2015, both became voluntary, which means that each school and class decides whether to participate. The tests are based on the competence aims in the national curriculum (Norwegian Ministry of Education and Research [KD], 2006, 2013) that are to be achieved by the end of lower secondary school (Year 10). In line with national tests in other countries, these are "used for early detection of reading difficulties. They help to identify the specific learning needs of individual students and to define appropriate personalised follow-up and teaching" (Motiejunaite et al., 2014, p. 972). In both tests, there are reading comprehension tasks in which the students are asked to find information, understand the main content, interpret, and make inferences based on various texts (UDIR, 2010a, 2010b).[1]

PROCEDURE

Based on my previous study (Brevik et al., under review), I was interested in identifying students in Year 11 who had participated in the national reading tests in Norwegian and English, and who had scored below the 20% intervention benchmark

in the Norwegian reading test, and above 60% in the English reading test. In my previous study, 4.5% of the students, identified as Outliers (n = 463), were identified to have this profile (Brevik et al., under review).

In order to identify the Outliers for the present study, I randomly invited five upper secondary schools in two different counties to participate. While all were willing, only two of the schools had participated in both reading tests. One of these schools provided the test results. At this school, only two classes had taken both tests, and these were both vocational classes. First, the school identified the students who had scored below the 20% intervention benchmark in the L1 test (n = 16), and at the same time 60% or above in the L2 test (n = 6). At the school, I was provided with the test results and validated the school's identification. The difference between the number of students with the Outlier profile (n = 6) and those willing and able to participate (n = 5) was that the sixth student had dropped out of school after taking the tests (September 2015) and before data collection (November 2015).

PARTICIPANTS

Table 1 presents a summary of the five students who were able and willing to participate. While one student attended the vocational programme Media and Communication (MC), the other four attended Electrical Installation and Maintenance (EIM).

Table 1. Participants: Background information

Student	*Vocational study programme*	*Gender*	*Born in Norway*	*Parents born in Norway*	*First language (L1)*	*Previously attended an English-speaking school*	*Test results in English (L2)*
1	MC	Male	Yes	Yes	Norwegian	No	100%
2	EIM	Male	No	Yes	Norwegian	Yes	75%
3	EIM	Male	Yes	Yes	Norwegian	No	82%
4	EIM	Male	Yes	Yes	Norwegian	No	90%
5	EIM	Male	Yes	No	Norwegian	No	71%

Note: L1=first language (Norwegian), L2=second language (English), MC= Media and Communication, EIM= Electrical Installation and Maintenance.

As shown in Table 1, all five students were boys in VS who defined Norwegian as their first language, although one was born outside Norway and another had parents born outside Norway. Student 2 was the only one who had attended an English-speaking school, which he did as an exchange student the previous year. In the final column, the students' total score on the English reading test showed that they had answered 71% to 100% of the tasks correctly.

DATA COLLECTION AND ANALYSIS

I conducted individual interviews with each of the five students (see Table 1). The first part of the interview consisted of a questionnaire with 12 questions that addressed their background and information about what they read in and out of school, in Norwegian and English (see Appendix A). The second part was an open-ended interview guided by one main question which asked them to elaborate on their English reading proficiency. The second part, which was videotaped and transcribed, had an average length of 10 minutes. The combination of the test results with the questionnaire and the open-ended interview increased the internal validity of the study (Johnson & Christensen, 2013).

After identifying the Outliers, the data analysis included three steps; first reading the survey questions related to the students' interests and motivation for English in school, then reading the survey questions related to their use of English out of school, and finally reading the transcribed interviews (see Table 2).

Table 2. Data analysis

Readings	*Aim*	*Tools of analysis*	*Research question*
1st step (survey questions 6–9)	To identify the students' interests and motivations for using English and Norwegian in school	Analysis using the concept-driven categories in Appendix 1	RQ1. What characterises these students' use of English in and out of school?
2nd step (survey questions 10–12)	To identify specific uses of English and Norwegian out of school		
3rdt step (interviews)	To identify the students' metacognitive awareness of reasons for their English reading proficiency	The students' expressed use of English and reflections on their English reading proficiency	RQ2. To what extent do these students provide explanations as to why they are better readers in English than in Norwegian?

RESULTS

In this section, I present results for each research question separately, before discussing these in the following section. Three patterns emerged when trying to understand why these Outliers were markedly better readers in English as the L2 than in Norwegian as their L1. First, these boys in VS confirmed my impression of being more proficient readers in English than Norwegian. Second, they revealed higher motivation for and mastery of English than Norwegian as school subjects. Third, all seem to have chosen English as their preferred out-of-school language; for example, they read the news, listen to music, watch TV series and films, and play online games in English on a daily basis.

To What Extent Are These Boys Better Readers in English Than in Norwegian?

Although the test results from the reading tests showed that the five participating boys scored below the 20% intervention benchmark in Norwegian, and 71% to 100% in English (see Table 1), I found it important to ask them whether this characterisation matched their impressions of themselves as readers. During each of the five individual interviews, I asked each participant the same initial question, as shown below:

Excerpt A. Better Readers of English Than Norwegian

Interviewer: When I say that my impression from the reading tests is that you are a better reader in English than in Norwegian, do you agree with this?

Student 1: Yes, in my spare time, I listen a lot more to English, like, text, I read it, I listen to it […]. Sometimes it is like I find it easier to express myself if I speak English. I might forget a word in Norwegian, and then I suddenly remember it in English.

Student 2: Well, I usually watch things, listen to things, and maybe a lot in English. So I, well, I play games in English, and then I read and write everything in English so it is, yes, well, presently it is in English, most of the things I do [in my spare time].

Student 3: No, not quite […]. I think that, well, Norwegian is the main language, and I use English a bit less, like, in general when I speak and stuff. [But] it might be that perhaps I am a bit surer in a way of how to express myself in English, or something like that.

Student 4: Yes. I might. I haven't considered it, really. […] I am a bit surprised, I didn't know. […] I listen a lot to English lyrics, and I listen to music with text that means something, to put it that way. […] But yes, I do believe so. I think that it's correct, yes.

Student 5: I don't think about it that often, really. It's not something I … I really don't know. It's not something I have pondered about. […] Yes, it might be so, I think. […] Yes, I usually analyse the texts thoroughly, so to speak, so that I understand what … what the content is about.

The quotes above show to what extent these boys viewed themselves as better readers of English than Norwegian. Interestingly, although four of the boys agreed to such a characterisation, they had not necessarily thought about themselves as readers of English before. Student 3 is not so sure he is a better reader of English

than Norwegian, and also underlined that he used Norwegian more than English, and his quote, along with the others', showed that they talked more about their *use* of English in general, than their *reading* of English texts. To examine more closely what these utterances might indicate, the following sections elaborate on their in- and out-of-school uses of English and Norwegian, focusing on their reading skills and reading activities in particular.

What Characterises These Boys' Use of English at School?

In the questionnaire, the boys compared their interests in Norwegian and English as school subjects and their reading comprehension in the two languages. The findings suggest that these two aspects are closely connected.

First, the questionnaire showed that these boys were more interested in English than Norwegian as school subjects. Despite this general trend, the boys' interest varied from two of them being a little interested in English as a school subject, two others being quite interested, and one being very interested. On a positive note, none of them answered that they were not interested at all in either of the subjects. To illuminate these findings I present two excerpts from the interview with Student 1, who not only stated that he was very interested in English as a school subject but also scored 100% on the English reading test (see Table 1). These excerpts show the fine line between being interested in the English subject and being interested in participating actively in English school activities.

Excerpt B. Choosing Not to Participate in English at School

Student 1: I actually don't say a lot in the English lessons and stuff. I keep mostly to myself. […] I tend to sit there thinking that I might raise my hand, but I don't bother doing it. I don't quite know why….

Excerpt C. Actively Participating in English at School

Interviewer: In your English lessons […] do you ever link your study programme, Media and Communication [MC], to the English school subject, or are your English lessons about entirely different topics?

Student 1: Well, right now we have this … we have included quite a lot of MC into our English lessons, so that we have these MC type of tasks, in English, like filming ourselves and stuff, making these video blogs.

Interviewer: And is that more interesting?

Student 1: Well, yes, I think it is interesting […] when I talk to the camera.

Interviewer: Right, and do you submit it to your teacher, or show it to the class?

Student 1: It doesn't matter. I think it is just fun if the entire class sees it […] because then I don't talk directly to anyone, which is somewhat easier, perhaps […]. It's just … the video camera is something individual in a sense, then you only need to talk, then you only talk to yourself and then someone listens to it afterwards.

In these excerpts, Student 1 highlighted how his interest in English as a school subject did not necessarily lead to his active participation in school activities; instead, his participation changed depending on the task.

One of the other participants also illustrated the importance of interest by indicating that how easy he found a text depended on the topic. He stated a preference for "just … something that is interesting, instead of reading about … Napoleon, because I don't find that very exciting" (Student 4).

Similarly, in the questionnaires, the boys indicated that they generally found it easy or quite easy to read school texts in English, and that they in fact found it just as easy as, or even easier, than reading in Norwegian. Along the same lines, Student 5 revealed that it was easier for him to understand English texts related to his study programme, than texts related to other topics:

Excerpt D. Reading English Texts Related to the Vocational Studies

Student 5: In our vocational subject, we […] kind of have a big topic in English within Electrical Installation and Maintenance.

Interviewer: Right. Do you find it more or less interesting than what you otherwise read in your English lessons?

Student 5: It is a bit more interesting … kind of. […] It makes things a bit easier … and then I can … you don't always end up working in a Norwegian company, and if you end up choosing a foreign company, then you would have to use English a lot…

Both of these boys (Students 4 and 5) revealed that seeing personal purposes for reading made it easier for them to understand texts in English; particularly when school texts were linked to their interests, their vocational study programme, or future work. It should come as no surprise that the students found it easier to understand English texts concerning topics of interest. More surprisingly, perhaps, is that they revealed reading more English than Norwegian out of school, by choice.

What Characterises These Boys' Use of English Out of School?

In the questionnaires, the boys stated that they read, listened to, and used English more than Norwegian in out-of-school situations (Figure 1).

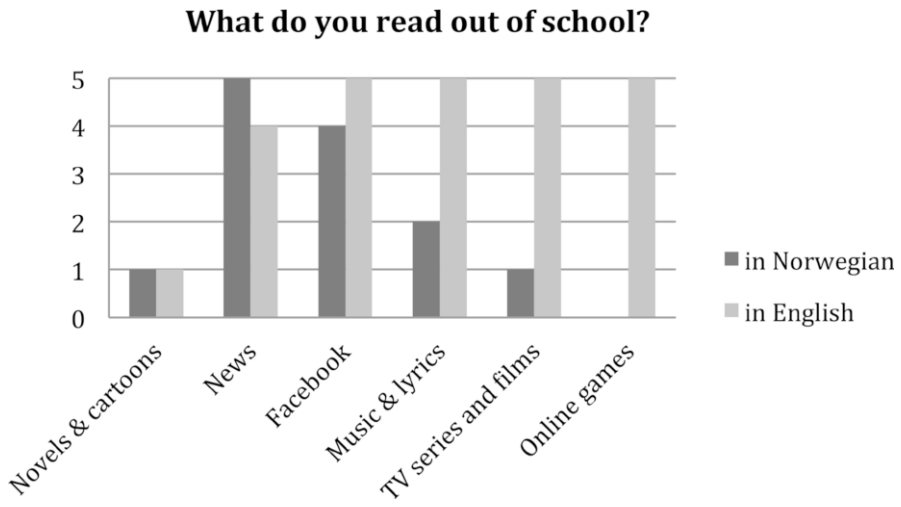

Figure 1. The students' answers to the question: What do you read out of school?

Four of them read the news and information on Facebook in both languages, revealing a pragmatic attitude towards the languages; in other words, they simply read the information they happened to come across in the language it appeared. They stated that they accessed the Internet via Facebook and primarily read their news feed, whether these were in Norwegian or in English. One of the boys explained how he chose to read and listen to the news in English: "Well, sometimes there are news videos, CNN or whatever it is, so then it's in English" (Student 2). He expressed a similar attitude towards reading novels and cartoons; explaining that he sometimes read in Norwegian and sometimes in English, depending on his interests. He clearly separated between his in- and out-of-school uses of language, as illustrated in interview excerpt E:

Excerpt E. A Pragmatic Attitude Towards Reading English Out of School

Student 2: I do … my homework and write everything in Norwegian, I do that, but in my spare time I read things in English, since cartoons, for example, are in English, like DC Marvel and those, the big companies, they use English, no matter what.

Interviewer: Do you read these on paper or online?

Student 2: On paper […] and then I also read things online … these Japanese cartoons in English since that is the only language I can translate from, so it's a lot easier.

Interviewer: In the manga series?

Student 2: Yes.

In this interview, Student 2 pointed out that he mostly used Norwegian at school and for school work, but that he used more English in his spare time. Figure 1 illustrates this notion of using English by choice, not only for Student 2, but for all five of the boys. In addition to their reading novels, cartoons, news, and Facebook in both languages, Figure 1 shows that, while two students listened to music and read lyrics in Norwegian and one of them watched Norwegian TV series and films, all five boys used English to listen to music, watch TV series and films, and play online games.

These out-of-school uses of English are elaborated in two interview excerpts, where Students 3 and 4 revealed how they used English on a daily basis, with Student 4 also explaining why:

Excerpt F. Use of English Out of School

Student 3: It is, well, a lot on the Internet, really, so, both communication and, ehm, other things to read, for example articles and stuff.

Interviewer: When you say "communication," is it online games, or other forms of communication in English?

Student 3: Yes, it can be … It is mostly online games … yes.

Excerpt G. Reasons for Using English Out of School

Student 4: Well, I think it is because when I read, like, I watch a lot of films and series […] and then I read about the series and stuff.

Interviewer: On the Internet?

Student 4: Yes.

Interviewer: Do you spend more time doing that than playing games?

Student 4: No, I don't think so.

Although none of the students reported to play online games in Norwegian (see Figure 1), all five said they played online games in English more than three hours per day on average. The exception was one student who had recently reduced the time he spent on online games to less than three hours per day. In the interviews, the students

elaborated on their time spent on gaming, as illustrated in excerpt H, explaining that gaming depended on both school work and relational activities with his friends:

Excerpt H. Time Spent on Online Games

Interviewer: When you play online games, like you said you did, do you play more or less than three hours a day?

Student 2: Well, it depends. You could say that, since sometimes I have a lot of homework and many tests, then I mainly focus on that. But when I have friends over and such, then I spend more time on that [gaming].

These boys in VS explained that they not only read the ongoing game instructions in English, but also used the chat function to communicate with other gamers in English. One of them used the written chat function only, and another used only the oral chat function, while the remaining three used both these functions actively while gaming. When I asked Student 3 whether he believed he had become a better reader in English due to his gaming activity, he responded, "It has probably helped, yes." Interestingly, however, the students did not necessarily see their gaming competence as something they could use at school, unless explicitly suggested to them, as illustrated in excerpt I:

Excerpt I. Gaming as a Potential Part of English Lessons at School

Interviewer: You tell me that you play online games – which games do you play?

Student 1: *Counterstrike* and such, strategy games.

Interviewer: Mmm, and you say that you learn a lot of English playing this game. If you learn a lot by gaming, is there any reason not to play this game at school?

Student 1: Ehm, well, I don't feel it is related to school, even though I learn a lot of English, or, well, I don't quite know.

Interviewer: I see, and it might be good to have something that is an out-of-school activity only?

Student 1: Yes.

Interviewer: What if your teacher, for example, said that you were going to learn about a conflict, like World War II, in your English lessons, and that you were to use an online game to learn about this war, in English. Would that be of interest?

Student 1: I think that would work well, actually, because then you would have the events in front of you. If you play, like, you would take part in the things that happen, and you would kind of be a person who has a major part in the events.

Although I asked each of the boys specifically how their gaming skills could be used in school, none of them saw this as relevant for their English school subject. Only in this interview, when I explicitly suggested how gaming might be used in English at school, did Student 1 see this as an option. However, when I asked how they could use their high proficiency reading skills in English as a resource for their peers, Student 2 pointed to his wide vocabulary, which he had learnt both through gaming and during his stay abroad the year before:

Excerpt J. Vocabulary Training as Part of English Lessons as School

Interviewer: What can you do, or demonstrate, or help the teacher with related to English, something you believe you would be particularly good at?

Student 2: Well, I could, for example, show some difficult words and some sentences that I have noticed the teachers never use… They haven't heard about some of the words that I have seen … that they don't know the meaning of, and then I can contribute with explanations.

The combination of the questionnaire and the interview data shows that, although these boys in VS confirmed my impression of being more proficient readers in English than in Norwegian, they had not necessarily considered themselves as English readers before. When asked *why* they were better readers in English than in Norwegian, their reasons were mainly linked to their choices of using English as their preferred out-of-school language; particularly playing online games on a daily basis. With one exception, they all characterised themselves as gamers, which implicitly meant that English was a prerequisite for being gamers. Paradoxically enough, although these boys used English in their spare time by choice, they did not see how their English proficiency could be transferred to school activities unless specifically being presented with the idea.

DISCUSSION

Initially, this chapter posed the question: *Why do some upper secondary students (16- to 17-year-olds) read significantly better in English than in Norwegian?* My main finding is that the identification of the students as either good or poor readers is not enough; we need to recognise that some students are both good *and* poor readers and then try to understand why, as well as what the educational implications might

be. Together, the analyses of the students' test results, questionnaires, and interviews support Koda's (2007) claim that reading in a second language is a complex phenomenon involving two languages. The analyses show the importance of taking the crosslinguistic aspect of reading in a second language into consideration, as well as the students' language use related to their out-of-school interests and engagement (Bernhardt, 2011). I first identified these students as Outliers (Brevik et al., under review). Given the massive amount of time they spend on online gaming, where English is their preferred language for communication, I have since labelled these students the "Gaming Outliers."

A Holistic View on Reading Competence

The results in this study show that the Gaming Outliers, who were good readers in English L2, but poor readers in Norwegian L1, were boys enrolled in VS (see Table 1). To the best of my knowledge, no prior study has identified reasons why boys in VS might be markedly better readers in an L2 than in their L1. These findings were most unexpected and challenge the notions that we are either good or poor readers (e.g., Grabe, 2009), or that a poor reader in the L1 is also a poor reader in the L2 (Bernhardt, 2011). It is about time researchers acknowledge that students' reading proficiency might display aspects of both good and poor reading proficiency depending on the reader, the text, the activity, and the sociocultural context (RAND, 2002), in individual as well as collective experiences of comprehension (Claxton, 2007; Daniels, 2005, 2008; Vygotsky, 1981).

Based on the view that the use of English reading takes place within a sociocultural environment, where there is an ongoing dynamic relationship between learners of English and the affordances and demands they encounter in school settings, their out-of-school use of English might be essential. These findings indicate that the Gaming Outliers' reading proficiency may well be due to their language use out of school, based on their interests and engagement in various media-related activities (e.g., Alexander & Fox, 2011; Alvermann, 2002), rather than their current L2 instruction. These boys watched English-speaking films and TV series on a daily basis; they listened to English lyrics and read the news in English. However, although these approaches are educational, they are rather passive approaches to language and learning (Daniels, 2005, 2008; Vygotsky, 1981). Therefore, it is quite interesting to note that the Gaming Outliers also spent more than three hours per day on online gaming, where they engaged in interactive communication in English through oral and written chat functions, as well as reading and acting on instructions as an integrated part of the game. Their motivation for learning English seemed to lie in a wish to improve their gaming proficiency, whether they played with international gamers or socialised with peers outside the screen while playing with friends in the same room. These findings are in line with national and international research suggesting that gaming involves complex reading and extended social interaction (e.g. Gee, 2007; Silseth & Aarseth, 2011; Steinkuehler, 2006, 2007, 2010).

In contrast, there is little doubt that playing "point and click" games like Angry Birds or Tetris does not make anyone improve their English skills. Rather, it is a matter of playing games that include a large amount of language, which requires the readers to understand, find, and interpret information, as well as reflecting on, assessing, and reacting to the content. These aspects of reading are prerequisites for the students to display and develop their English reading competence (KD, 2006, 2013; UDIR, 2012).

Resources at School

The Gaming Outliers have chosen English as their preferred out-of-school language. At the same time, these boys clearly separated between in- and out-of-school language use; suggesting that a change of teaching approaches in the English school subject might be profitable, by including the students' interests and engagement to enhance their motivation for learning.

The findings in this study also show that the Gaming Outliers were interested in learning vocabulary to perform well in these online games, which is in line with Sundqvist and Wikström's (2015) findings, where gamers used longer and more complex English words in their national writing tests compared to non-gamers. The conclusion in this study was that the gamers' English skills were transferred from one context (e.g., out-of-school) to another (e.g., in school). Indeed, if the Gaming Outliers read English rather than Norwegian out of school, they were probably exposed to more vocabulary in the L2 than in the L1. This might explain their reading markedly better in the L2. I would therefore contend that the Gaming Outliers provide an example of how important interest, relevance, and systematic exposure may be for language and vocabulary learning, to the point that students may develop better L2 than L1 reading proficiency. In turn, these findings point to the importance of taking such factors into consideration in L1 and L2 instruction in general, and reading instruction in particular.

A very important finding in this study is that these adolescents did not see the educational profits of their out-of-school English usage. They might therefore profit from their teachers asking them what they use English for out of school, and why it is important to them to learn the language. Likewise, asking them what they like about online gaming, and whether they believe it improves their English proficiency might prove useful. This is not only a matter of showing interest as teachers, but might also help develop these Gaming Outliers as English readers. The teachers play an important role here, in line with the findings in previous research (Brevik, 2014, 2015; Brevik & Davies, 2016; Silseth, 2012; Silseth & Aarseth, 2011). It is not an aim to include as much gaming in school as possible, but teachers should be encouraged to use their students' English language engagement positively and actively in the classroom – be that gaming or other interests. Doing so might contribute to the students' motivation for learning English.

The Vygotskian approach to pedagogy therefore requires us to recognise how teachers use students' out-of-school interests, but also other resources, to engage students with powerful cultural meanings and ways of working (Claxton, 2007; Vygotsky, 1981). It consequently has a contribution to make to reading research theory by establishing a need to focus on how the teacher and the learner engage with cultural meanings. The argument is that drawing on cultural meanings in school has the potential to expand teachers' knowledge of students; while seeing them as active in their own development as English readers, thereby resulting in the affordance of a pedagogy that meets the needs of students (Claxton, 2007; Vygotsky, 1981). In addition, one aspect of their active learning is that students can learn how to use their out-of-school interests as a tool, creating demands on themselves which help them move forward as learners, by helping them to monitor and control their own progress.

CONCLUSION AND AVENUES FOR FURTHER RESEARCH

This study suggests that students in upper secondary school who are markedly better readers in English than in Norwegian spend a lot of time playing online games in English. Based on these findings, it is tempting to suggest that online gaming makes adolescents better English readers; however, the findings need to be interpreted with caution. What the findings do suggest, though, is that some students who are proficient English readers play online games on a daily basis; reading instructions as well as communicating in oral and written English with other gamers. Whether these findings also indicate that gaming improves English proficiency is a topic for further research. Nevertheless, as these students were at the same time among the most proficient readers in English as their L2 and among the poorest readers in Norwegian, which was also their L1, these findings are worth noting. I urge educational researchers and politicians to acknowledge that this is more important than identifying those who score below the intervention benchmark. In this manner, we can build on the students' strengths instead of mainly repairing their weaknesses as isolated traits. This could be a rewarding way of acknowledging the students' holistic reading competences.

In conclusion, based on the identified Outlier profile (Brevik et al., under review), it seems that there is a relationship between reading in English as the L2 and variables in the unexplained variance (Bernhardt, 2011), like interest, motivation, and engagement; even though there is no relationship between reading in the L2 and their L1. It also seems that enabling the Gaming Outliers in the present study to read in their areas of interest and expertise, like out-of-school gaming, improves these boys' English reading skills in school as well. These aspects are particularly relevant for further research, as well as school reading instruction and testing. It will be interesting to follow future research in this area, and I hope to contribute in this avenue of research.

NOTE

[1] In the L1 test, there is an additional decoding test, and in the L2 test, there is an additional listening test. Since neither test measures reading comprehension, they are not included in this study.

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APPENDIX

Questionnaire: English at upper secondary school

1. Your background:
   - ○ Boy in vocational studies
   - ○ Boy in general studies
2. Which study programme do you attend?

   [ ]

3. Is Norwegian your first language?
   - ○ Yes
   - ○ No

4. If no, what is your first language?

   [ ]

5. Have you previously attended an English-speaking school?
   - ○ Yes
   - ○ No
6. How interested are you in English as a school subject?
   - ○ 1. Not interested at all
   - ○ 2. A little interested
   - ○ 3. Quite interested
   - ○ 4. Very interested
7. How interested are you in Norwegian as a school subject?
   - ○ 1. Not interested at all
   - ○ 2. A little interested
   - ○ 3. Quite interested
   - ○ 4. Very interested
8. How easy or difficult do you find school texts in Norwegian?
   - ○ Easy
   - ○ Quite easy
   - ○ Difficult
9. How easy or difficult do you find school texts in English?
   - ○ Easy
   - ○ Quite easy
   - ○ Difficult
10. What do you read in Norwegian outside school?
    - □ News
    - □ Facebook
    - □ Novels
    - □ Magazines, cartoons
    - □ Online games
    - □ TV series and films
    - □ Music and lyrics
    - □ Other
11. What do you read in English outside school?
    - □ News
    - □ Facebook
    - □ Novels
    - □ Magazines, cartoons
    - □ Online games
    - □ TV series and films with Norwegian subtitles
    - □ TV series and films with English subtitles

- □ TV series and films without subtitles
- □ Music and lyrics
- □ Other

12. If you play online games, which functions do you use, and how much do you play?
    - □ Written chat
    - □ Oral chat
    - □ Less than 3 hours per day
    - □ More than 3 hours per day

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INGVILL RASMUSSEN

4. MICROBLOGGING AS PARTNER(S) IN TEACHER-STUDENT DIALOGUES

A Case Study in the Subject of History

INTRODUCTION

The questions raised in this chapter are based on an overall interest in exploring how computer tools can enhance existing and promote new forms of classroom dialogues. In everyday use, 'dialogue' means conversation – talking together – but theoretically, within sociocultural approaches to learning, dialogues have a much more profound and foundational meaning. This is a broader and more abstract application of the term 'dialogue', referring to 'any kind of human sense-making, semiotic practice, interaction, thinking and communication, as long as these phenomena are "dialogically" (or "dialogistically") understood' (Linell, 2009: 104). Dialogues can be seen as a very specific use of language, a use that aims to help people to 'interthink' (Mercer, 2000) in order to understand one another's knowledge and perspectives. As Vygotsky and Bakhtin remind us: our individual 'psyche' is filtered through our cultural context – where language is our most prominent culturally developed tool (Bakhtin, 1981; Vygotsky, 1986). However, our cultural contexts and the way in which we use language to communicate or engage in dialogue are always changing. Today, our communicative situations have become increasingly digitalised. Technologies have influenced many parts of our lives – school, work and home – in ways that make it relevant to describe them as 'partners in conversations'. Services like instant messaging, chats and various social media sites have created opportunities for dialogue that are digital, or a mix of digital and face-to-face, and such services have become central in both private and public communication.

A key format of these digitalised dialogues is the message format called microblogging, characterised by short and real-time posts. A range of important Web 2.0 and social media environments contain various forms of microblogging. The best-known microblogging service is Twitter, in which the blogs are restricted to 140 characters. Other Web 2.0 services also contain similar communication formats but refer to them as 'status updates', e.g. Facebook. Microblogging is thus a relatively broad term and may be used to signify 'any kind of activity involving posting, be it on a social network site or a microblogging site'.[1] As these new communication

E. Elstad (Ed.), Educational Technology and Polycontextual Bridging, 63–82.
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formats are picked up in various contexts, we see that it their potential to support educational activities is beginning to be noted. The focus in studies on early adopters seems to be mainly on enhancing the opportunities for students to practice written communication skills, both with each other and with global audiences (e.g. Lantz-Andersson, 2016). However, the opportunities this technology provides for teachers to obtain insight into the discussions of student groups, and to represent those discussions for whole-class conversations have also been noted (Lantz-Andersson, 2016; Mercier, Rattray, & Lavery, 2015). The few studies that exist on microblogging in formal education indicate that the short format is productive for starting conversations and for supporting collaborative learning, making thinking visible through tangible artefacts (Gao, Luo, & Zhang, 2012; Mercier et al., 2015). Furthermore, it seems that microblogging may change participation in groups thanks to new opportunities for prompting/directing and visualising participation. There is consequently a general agreement that we need to know more about how these new Web 2.0 tools affect and alter the ways in which we communicate, make sense of our world and learn, and how they may be used productively for learning in formal education.

This chapter reports on research projects in which researchers, technology developers and teachers designed a microblog service to support teachers' subject practices and create a higher number of good-quality dialogues in the classroom. We designed a microblogging tool with the aim of supporting the teachers' work as discussion facilitators by providing awareness of the pupils' work and a representation of this for whole-class conversations. The pedagogical and technological design draws on many years of empirical research and a lengthy partnership with a group of teachers at a school in Oslo, Norway, where we have been exploring, co-creating and evaluating technology for educational purposes by tweaking well-known and available net-based services, such as wiki, chat rooms and blogs (Lund & Rasmussen, 2008, 2010; Rasmussen, Lund, & Smørdal, 2012). The following empirical questions will be addressed in the analysis:

- How did the microblogs become structuring resources in the student – teacher interactions within whole-class settings?
- What are the students' experiences of using microblogging during class activities?

In the next section, the central research findings that were used as a baseline for the design of the microblog service will be described, before moving to the analysis of how a history teacher used microblogging to engage students in discussing the different versions of nationalism that arose in the period prior to the First World War. The data is from an ordinary history class in a Norwegian senior high school. The chapter closes with accounts from students about their use of microblogging and a discussion about how the teachers and the students appropriated the microblogs in their interactions and dialogues in classrooms.

Dialogue and Technology Use in Whole-Class Interactions

Influenced by Vygotsky's theory in which learning is seen as the internalisation of initially social and communicative activities scaffolded by more competent partners (Vygotsky, 1986), much of the research that laid the ground for the current perspectives on classroom discussion focused on metacognition, reading comprehension and strategy instruction. A core focus in this research has been on discussion as a tool for developing background knowledge and supporting sense making and knowledge construction before, during and after, for example, reading activities in classrooms (Kamil, 2011). In these studies, talk and dialogues are seen as a means for the students' acquisition of specific strategies and skills (Perfetti, Yang, & Schmalhofer, 2008). Acquiring strategies and skills (such as how to narrate, summarise, argue, make claims, etc.) are crucial for partaking in many learning activities. It is also crucial to learn the skills needed for collaboration with peers. Importantly, this line of research has brought to the fore the fact that most people find collaboration valuable but also challenging, and that learning outcomes from collaborative tasks are related to the quality of the interaction processes (Kuhn, 2015). It has also been shown that there are large variations among students in their collaboration and communication skills. Some students learn such skills at home and through various out-of-school activities but many are rarely encouraged to present their ideas or to take part in dialogic discussions outside the classroom (Hart & Risley, 1995). Initially, within this field, less emphasis was placed on examining how humans mediate the cultural context for learning through talk and dialogues. Our perception and creation of our contexts emerge through the mediational means appropriated, i.e. concepts and language-based classification systems. One might describe the development of the field of educational studies of talk between teachers and students as having moved from focusing solely on talk as a tool for creating strategies and skills to also emphasising forms of talk and dialogues as essential in creating how we think and how we view our world (Lawrence & Snow, 2011).

Alongside the interest in talk and discourse between teachers and students, there has also been a growing body of research concerning how technology can facilitate different types of dialogue and interaction in classrooms. Studies have investigated how the features of these new technologies can support dialogic learning and many scholars have investigated how teachers might use dialogues to encourage students to articulate and reflect on their own understanding (e.g. Alexander, 2011; Hamre, Pianta, Downer, DeCoster, & Mashburn, 2013; Mercer & Littleton, 2007). A number of case studies have been conducted following the investments in Interactive Whiteboard Resources (IWBs) in many countries. A recurring finding is the influence that the large interactive screen has on interactions and dialogues. Highlighted are teaching practices where the up-take of interactive screens supports dialogic teaching. Here, the value of shared screens is linked to the guiding and scaffolding

of students and the development of understanding (Hennessy, 2011; Hennessy & Warwick, 2010). When engaging students in the process of comparing ideas, shared screens facilitate ways of making differences between perspectives more explicit (Gillen, Kleine Staarman, Littleton, Mercer, & Twiner, 2007; Warwick, Mercer, Kershner, & Staarman, 2010). Hennessy, Deaney, Ruthven, and Winterbottom (2007) observed lessons combining group work and whole-class discussions using IWB and where the activities were organised depending on the students' contributions. The whiteboards were, for example, used to work collectively with student texts. By reading and discussing the texts viewed on the board, the students were able to explore and discuss their ideas collaboratively. In such cases, the whiteboard facilitated a space for both co-constructions of content and discussions of representations; the analyses found that the teachers took a more facilitative role, contributing to the learning process by making suggestions and asking open-ended questions. Hennessy (2011) notes that IWBs facilitate new opportunities for learners and teachers to express, explain, justify, evaluate and reformulate ideas by the use of different representational resources. IWBs afford effective and flexible ways of sharing and manipulating material, which can support dialogic interaction and non-authoritative dialogue (Gillen et al., 2007). However, how teachers make use of the potential affordances of such screens may vary significantly. As Smith and colleagues pointed out in their early review of IWB research, the presence of an efficient presentation tool in the classroom may also lead to teaching that is less interactive and more didactic (Smith, Higgins, Wall, & Miller, 2005). A large-scale study subsequently confirmed this to often be the case (Smith, Hardman, & Higgins, 2006).

While research has investigated talk around computers and IWBs, there is not as much rigorous, in-depth research into situations in which students are dialogically active through software and where student outputs are systematically shared for joint discussion in the class. As mentioned in the introduction, microblogging may help students to be more active in classroom interaction that involves sharing their developing ideas, in turn promoting positive dialogic interactions. Gao, Luo, and Ke Zhang (2012) have published a content analysis of twenty-one studies of microblogging used in educational settings; the tool used in most of these studies is Twitter. Their review of the results shows that even though microblogging is not specifically designed for conversations, the blogs/tweets often start conversations. Increased participation and engagement are also reported across the studies reviewed by Gao, Luo, and Ke Zhang. The authors conclude that increased participation and engagement may be attributed to several reasons but that microblogging seems to offer a convenient tool to express ideas and this seems to encourage some students who otherwise may not be active to participate in class (Gao, Luo, & Ke Zhang, 2012). It has also been suggested that microblogging can support practices relevant for collaborative learning, such as publishing and sharing learning processes, supporting and achieving collaborative tasks and making thinking, collaborative processes visible through tangible artefacts (Hsu, Ching, & Grawbowski, 2014;

Mercier et al., 2015). Drawing on empirical case studies of Twitter use in higher education classes to support collaborative learning, Mercier et al. (2015, p. 96) argue that '[T]he use of Twitter to support collaborative interactions within and between groups, provides a different model for classroom participation behaviours … a more democratic form of knowledge construction can be made available through the use of such tools'.

On the basis of the findings described above and bearing in mind that teaching depends heavily on how teachers appropriate specific tools as part of their teaching practices, we designed a technology aimed at supporting teaching that is dialogic, that is, 'collective, reciprocal, supportive, cumulative and purposeful' (Alexander, 2008, p. 105). Since the short communication format of microblogging has become commonplace to express ideas, we wanted to include it to encourage students who otherwise may not be active to participate in whole-class dialogues, supported by their teacher. Hence, we used microblogging to facilitate teachers' dialogic interactions with their students, given that this format may hold productive potential for starting conversations. Microblogging was also selected to prompt students' to engage with, share and discuss the subject content by requiring them to summarise/reduce text information – in microblogs – and to bring these microblogs into the whole-class discussion. Most classrooms today are equipped with either a PC projector or IWB. In the design, we wanted to draw on this computerisation of the traditional blackboard and provide an additional support for the joint creation of knowledge and understanding by projecting the microblogs onto a screen or IWB as a visualisation of 'interthinking'. Opportunities for interactions on a shared screen hold productive potential for teachers when they guide their students' construction of knowledge and understanding (de Jong & Jules, 2005). As such, this design effort can be seen as an attempt to bridge youth culture and school culture by including a communication format that young people use outside of school in whole-class dialogues to facilitate academic skills.

METHODS AND EMPIRICAL CONTEXT

Participants, Data and Analytic Procedures

Case study research starts from an interest in contributing with a deep understanding that will hopefully result in new insights into how humans make sense and learn in real-world contexts (Yin, 2013). This case study reports from an ordinary history class in which the students (17–18 years old) were attending a public upper secondary school outside one of the larger cities in Norway. The teacher was in his mid-thirties. He presented himself as fond of his main subject, history, and as interested in developing his professional expertise in applying technology. An enthusiastic computer gamer and role-player, he expressed his belief that such activities can be productive in learning. His interests have led him to participate in several research and development projects.

A rich set of data was collected during the course of this research, consisting of video recordings, field-notes, pupil products (essays and microblogs), group interviews of all students in the class and log data. However, since the present study focuses on how the microblogs structured the teachers' dialogues and interactions with the students, the video-recorded whole-class session, together with the log files (automatically saved and retrieved through the microblogging tool) and students' accounts in interviews constitute the core data for the present in-depth analysis. Video has several advantages when the focus of the investigation includes social interaction and the use of different types of resource in real-world settings. It allows us to study the temporal moment-to-moment organisation of talk and actions and to witness how the resources are used to conduct certain actions. The interweaving of the functions of talk, actions and resources can then be investigated. Detailed analysis of videotaped interactions makes it possible to describe the dialogic interactions that the teachers and students employ. The overall analytical approach to the analysis of the video data can be described as inductive but also as closely intertwined with the sociocultural perspective, as outlined (Vygotsky, 1986). From this perspective, studying interactions is considered well suited for approaching how humans learn in real-world contexts like a classroom.

Given the research interest in studying how microblogs structured the interactions in whole-class discussions, we video-recorded this setting. The data was transcribed and has been analysed by drawing on detailed micro-analytic techniques for interactions (Derry et al., 2010). The examples from the whole-class session, including verbal interactions and examples of microblogs, have been selected to illustrate the main findings from the qualitative analysis. Together, the examples demonstrate how the microblogs structured the teacher's dialogues with the students and what characterised these interactions. The interview data is used to get an impression of the students' experiences. The purpose with the interviews was to elicit how the students subjectively interpreted and experienced the learning activity that included microblogging (Denzin & Lincoln, 1998). The students were asked in groups to give accounts of the learning activity, to recount how they had used the microblogs and to evaluate the usefulness of the tool. I analysed the interviews by reading through the transcripts, identifying reoccurring topics (Braun & Clarke, 2006). The themes that emerged from the analysis did not necessarily overlap with the topics that the students were asked about. Since the interviews were not tightly structured, new themes naturally emerged during the conversation, based on the contributions from the students and the follow-up from the interviewer. The students' accounts of using microblogging are reported in the Discussion section.

Microblogging and Empirical Context

Drawing on the research described, we designed, in collaboration with the teacher, a microblogging service named 'Socius' (available for free download on App store). Socius was developed for three main use scenarios: computer-based individual work,

group work and whole-class dialogues. To bridge individual work and group work, we provided a chat/blog window that was arranged as an overlay to a web window with the class wiki. The design idea was to draw on the short format of microblogging to help the students to engage deeply with the content by providing them with opportunities to summarise or reduce text information (in microblogs) and to be better prepared for group work through the capacity to send the blogs to their group. The group work was facilitated by one tablet (iPad) per group. To share with the rest of the class the result of the group work, each group was able to 'take the stage' by toggling the 'share' button and thus send the current view to a PC in the classroom connected to a projector. Each group could take control at any time, creating a fluid transition between the groups. We provided a tablet that enabled the teacher to move freely within the classroom during the whole project and at the same time answer 'live' questions from students and give general instructions to all students.

Figure 1. Group work and whole-class activity

When it came to the teacher's use of the microblogging tool and his planning and enactment of the instructional design, the researcher and developer team did not take part. This division was important to secure the teacher's agency and autonomous use of tools developed in design-based research projects. The teacher appropriated the microblogging tools as he wished. In this way, the intended and the enacted design is separated, and the analytical attention is directed towards the teacher's own pedagogical design, appropriation and *in situ* interaction. The next section presents the results from the analysis, starting by describing how the curriculum unit unfolded, drawing on the data described above.

RESULTS

Microblogging in History: Sharing Countries' Perspectives on the Rise of Nationalism at the Start of the 20th Century

The history teacher used Socius in a project that lasted for three lessons on each of two days, with a week between the two days. The topic was nationalism and

democratic development; specifically, how different ideologies created tensions in Europe in the period leading up to the First Wold War. The students were given the task of representing a country in a historical role-play of a meeting in which the rise of nationalism at the start of the 20th century was addressed. This activity was inspired by jigsaw principles (Aronson et al., 1978) in the sense that it was an information-gap exercise. The students divided into country groups representing different perspectives on the same phenomena, namely, the rise of nationalism and its implications.

The project started with a preparation period consisting of an introductory lecture based on a chapter in the students' history textbook, after which the students were asked to write brief individual essays to familiarize themselves with the topic. The students' central resources were the history textbook and texts from the Internet. The students used a wiki to write short individual essays as a starting point for the thematic exploration. On the basis of this work, the students wrote microblogs. The students were assigned one of the five major European countries of the time: Italy, Great Britain, Austria-Hungary, Russia and Germany. They were instructed to apply relevant hashtags to their messages in order for the relevant group to be extracted, i.e. #Italy, #Great Britain (each group was assigned a nation).

To prepare for the role-play, the students assessed and negotiated the microblogs sent to their country group, wrote new ones, and organised their statements spatially on the tablets. Finally, the groups took turns presenting their work during the historical role-play. Each group's tablet was associated with a nation[2] and the microblogs were viewed when the students toggled the 'share' button, thus sending the current view to the PC connected to the projector. The desks were set in a horseshoe and the students were seated according to their country groups. The name of the country was written on folded paper and placed in front of the groups. The teacher dressed up – wearing a fake moustache and a hat, he made a point of locating himself in a different time and place when he introduced the role-play.

> Teacher: Dear nations of Europe. We see that the powers of nationalism are many and strong across Europe today. We are now entering a new century – the year is 1900 – and it may look like we are entering the century of nationalism. For some of us, this represents new opportunities, but for others it may represent a big threat. Shall we encourage these movements? Shall we even make changes in our countries' borders? Or shall we fight against these movements and continue with the Europe that we know and that works well. What is your country's view on this issue?

The teacher spoke in a theatrical and playful way, framing the learning activity as a historical role-play. The dramatic form also underlined the essence of the historical period they were about to enter. The period prior to the First Wold War was dramatic and the decisions that were made came to have a huge impact on how history unfolded in the next century, often characterised by historians as 'the age of

nationalism' (i.e. Eric Hobsbawm and John Keegan). The teacher also posed a series of questions, closing with the specific call to the groups of students representing nations in Europe: 'What is your country's view on this issue?' When he said this, he would call on a group to 'take the stage' and to start presenting their country's view on the rise of nationalism in Europe, and by so doing to take part in re-enacting the mentality of the historical period.

Group Presentation and Teacher Follow-up

The groups took turns presenting while their microblogs were viewed on the whiteboard in front of the class. In most groups, the students took turns and all contributed something. Typically, they more or less read from their blogs, added comments and summarised their main contributions. The first example illustrates this and how the microblogs structured the teacher's way of following up on the students' group presentations. The data is from the group representing Italy and we enter their presentation at the very end.

> #Italy: Nationalism is an ideology that is about the idea that people with the same background, the same traditions and the same language stay together and create their own state.

Italy student1: Nationalism is an ideology that is about the idea that people with the same background, the same traditions and the same language stay together and create their own state (reads from blog present on the screen).

Italy student2: Yes. We believe that, by hearing our history, you can understand why we in Italy are pro-nationalism; it has made us stronger and it has made us a united country, in contrast to the many small countries that we used to be before. We feel that it is better to be one big country than many small countries and this strengthens us against potential enemies.

As we see in this example, one student reads a blog aloud for the class. This was done in most groups. The blog that is read here describes and summarises this group's understanding of the term 'nationalism', as seen from the perspective of representatives from Italy. Then another student in the group takes over and presents the closing statement. This closing statement introduces Italy's history as the reason for their stance towards the rise of nationalism in Europe. The student says, 'We believe that, by hearing our history, you can understand'. The student refers back to the group's presentation. While talking, the student pointed to the blogs that were

visible in front of the class where it is written that Italy used to consist of several small states.

After this closing statement, the teacher takes over. Instead of asking the next country to present its story or giving direct feedback himself to the Italy group, he calls on the representatives from another country to respond. The teacher calls on Austria-Hungary:

Teacher:	It would be very interesting to hear what Austria-Hungary has to say to the claim that it is better to be one big country than many small ones.
Austria-Hungary student:	We are full of minorities – what can we do? (talks with a low voice)
Teacher:	YEEES!! Let us hear that! Louder!
Austria-Hungary student:	We are full of minorities – what can we do?

Since the teacher had designated himself the centre of the role-play, it was natural that he should orchestrate the interactions and call on the students to respond to each other. In the above example, the teacher took the closing statement from the Italy group into account and called for a response from a country that might have a different view of this version of nationalism. The student that responded, representing Austria-Hungary, took on the role and talked from the perspective of his country, saying with a low voice, 'We are full of minorities – what can we do?' The teacher responded enthusiastically and asked the student to repeat what he just said so that all could hear. As we see, the teacher is here the one calling for the students to respond to each other, refraining from providing the answer himself and in effect enhancing the opportunities for the students to elaborate on each other's contributions about the central issue of the impact of a position on nationalism in relation to another country. The student's reply draws on his group's presentation and it is worth remembering that he had a tablet with the group's microblogs on his desk. The teacher's enthusiasm was probably due to the fact that this student rarely talked during class, but also because he took on the role, attempting to speak from the point of view of a representative from Austria-Hungary at the beginning of the 20th century. The student brought to attention a central dilemma that the rise of nationalism evoked in Austria-Hungary in the preface to the First World War.

These first extracts show how the teacher introduced the whole-class session by modelling how to go about the task: through his words, way of speaking, gestures and props. And when he invited the students to take part, he did so by asking the students to make use of what they had prepared in a particular way, namely, in a historical role-play. By creating this context, the teacher also encouraged the students to playfully try out their knowledge (Lawrence & Snow, 2011) and, as we can see, the students responded by taking on the roles that expressed contrary views. Together, they brought to the class's notice that Italy and Austria-Hungary

did not hold the same view on the rise of nationalism during this particular historical period. Furthermore, a greater portion of students participated only vicariously in most whole-class discussions and there were also, in this case, some students who participated more than others. Nonetheless, as the extracts above show, microblogs seemed to play a role even for those students who were less vocal. While some students read the blogs aloud, the presence of the blogs seems to help other students to create a response.

Students' Perspectives and Teacher's Meta-Reflection

The next example is selected to illustrate the teacher's use of the microblogs and stem from the end of the session. By then, all country groups had made their presentations and after each presentation the teacher had called on other countries to respond. By doing so, he had engaged the class in discussions in which the students responded to each other. In order to round off and close the role-play, the teacher asked all groups to contribute with a final closing statement and to write short blog entries that could represent their stance (see blogs below).

#Russia: Europe should be governed by Russia, Italy and Germany.

#Austria-Hungary: d'être is our conclusion! Peace and alliances.

#Germany: We see that several countries are pro-nationalism – that is good, but also Great Britain and Austria-Hungary must give in.

#France: We will make sure that nationalism does not come in the way of our liberal values.

#Great Britain: We do not give in! Despite the fact that the nationalists are in the majority! We will remain liberalists! WAR!

These microblogs show the groups' conclusions and demonstrate the application of different versions of nationalism. The group representing Russia concluded that the strong powers of the time should have more of a say – a version of superpower nationalism. Austria- Hungary had, as we have seen, expressed concerns about the rise of nationalism. In their closing statement, the group used the French expression 'd'être' from *raison d'être* (reason for being) and they add that 'peace and alliances' are the way forward, acknowledging the difficult position that Austria-Hungary

was in at the time, and which saw the empire broken up after the war. The students representing Germany expressed in a forceful tone a militaristic version of nationalism. The groups representing France and Great Britain had both struggled and discussed the relationship between liberal values and nationalism and this is expressed in their statements.

The teacher read the statements aloud, commenting on the countries' concluding statements and adding issues or correcting what was missing. For example, he pointed to the blog from Great Britain and referred back to an earlier exchange between the students representing Italy, Austria-Hungary and Great Britain about nationalism in a country with colonies, adding, 'Take, for example, the British. They are very pro-liberalism and have a parliament – an elected parliament and that is great'. Importantly here, the teacher pointed to the screen and the blog by Great Britain, noting that they themselves had also written that the British were imperialists and that imperialism is not liberal. He then said, 'And someone challenged you: what if the people in your colonies become nationalist? But it is still a bit early to think like that!'

In this way, the students' often mundane or fact-oriented contributions were elaborated on and made more historical and conceptual by the teacher. As mentioned, he pointed to the students' blogs and used the words written by the students as a point of departure for his elaborations. He also actively referred to the blogs when he called on the students to respond to each other. In this way, the blogs became a shared resource in the whole-class discussion. The teacher closed the role-play in the following way.

> Teacher: It is fun to hear you arguing and part of the purpose with this is – or what makes it different than to sit with a textbook and make notes and have a test – is to play with history and try to think and understand from the point of departure of a given source. That we learn something and then try to reason – what must they have thought back then? How must they have experienced the situation? What were they afraid of and what did they see as possibilities? I think that is good performance in history if one can manage to think in this way. You have practiced this.

Note that the teacher expressed appreciation of the students' engagement and that he encouraged the students not to be afraid of making mistakes, but rather to 'play with history'. In history education, it is a central goal to understand the world from the context of those once living in it (Wineburg, 2001). In the above case, we have seen how one teacher used role-play to enact this part of the subject as reflected in the Norwegian history curriculum, in which historical empathy is included as one of the main historical perspectives (KL06). It is difficult to engage students in this specific way of talking and reasoning, but this teacher's pedagogical approach and his way of talking and acting out the role-play seemed to achieve this. To manage the shifting of perspective, the teacher used props (a fake moustache and a hat) to

underline the frame of the activity and the shifting between the here and now and back in time, helping the students to take on perspectives from a different time and place.

The presence of the microblogs, on the other hand, seemed to create new opportunities for taking part – or new ways of entering the whole-class discussion for some of the students. Since the tool facilitated sharing, both in the groups and in class discussion, all students gained access to each other's statements. In other words, the intervention facilitated the students' ability to externalise and bring with them ideas and arguments across activities, making these available for all. During the class discussion, the microblogs viewed at the front of the classroom provided the teacher with access to the students' own reflections and ideas. We found that the teacher used the students' own words and that he elaborated on their contributions during the class plenary session. In this way, the microblogs functioned as a shared point of reference as well as a resource for the students to communicate their arguments and reflections to the rest of the class and the teacher.

The Students' Experiences of Using Microblogging

The two issues addressed above – the different perspectives in history and the role of the microblogs – were also topics that the students took an interest in. After the class session, we asked the students about how they had experienced this unit and to evaluate the usefulness of microblogging. The purpose of the interviews was to elicit how the students subjectively interpreted the learning activity. Analysing the transcripts from the interviews, the two issues mentioned emerged as central. Often, the topics overlapped as the students talked; the following exchange from one of the group interviews may suffice as an illustration.

Student D: After that discussion – the one with the different countries – that was when I understood. When we took on different perspectives.

Student E: It was livelier, and in the class, we became more collaborative.

Student F: Yes – at least in the chat, when all started to talk more together.

Student G: And it seems that most in our class were interested. It was not like people were bored.

Student E: Instead of only sitting and reading – to have some variation.

Student G: Yes, variations.

The experience of taking on and talking from a specific perspective are here addressed by the students, both as a learning experience – that was when I understood – but also as a positive social experience. The latter was contrasted to everyday schoolwork, described here as just sitting and reading. Another student group had a somewhat similar exchange about the experience of using microblogs.

This group talked about the benefit of the jigsaw-inspired task – that more information was revealed to them along the way. This student group also appeared to be inspired by the gradual emergent realisation that there were differing versions of nationalism.

Student H: I think what I learned most from when we were sitting around that table, or when we started to talk and were different countries – then I thought: what kind of ideology did Germany have? What did they want? And then you sit and listen to the others – no, Italy also wanted … and Great Britain did not want – and you listen to a bit of the differences in what they wanted. And when you have to sit and listen because there might be someone who will argue against you and then you need a counter them, then you know what they want.

Student I: Hmmm, agree.

Student J: Well, I got a better understanding of what the different ideologies are about, like Fredrick said. You listen and, like, Germany said that, and Italy this, and in addition, you read the blogs and the textbook, you cover several issues.

The students provide accounts of the experience of reasoning from a specific perspective and listening to others with other perspectives. Student H is providing accounts of how he was thinking, which seems to be recognised by his peers. The role of the microblogs and the content are only addressed explicitly when student J takes on a more holistic approach and says that the diverse activities of talking, listening and reading the 'blogs and textbook' helped them to cover several issues. The microblogs were addressed most explicitly and frequently when the students talked about the activity as a variation from the ordinary. However, the students also reflected on formulating and sharing short statements in microblogs (reduction of text information) and they talked about how the blogs provided access to each other's ideas.

Student A: Yes we did that (reduced text information) in keywords and we remembered what we had talked about, what we had talked about in class – that was useful.

Student B: Then you got to see what the others had to say.

As noted in earlier research on discussion and argumentation, different views are often not made explicit in whole-class talk. The students' accounts show that they appreciated the opportunity to engage with the subject knowledge in a role-playing jigsaw-inspired talk. Different views emerged and became apparent to them when they listened to each other, wrote and read blogs. More importantly,

but less explicitly addressed by the students, was the importance of the teacher's interventions to create a discursive field driving students' construction of knowledge and understanding further.

DISCUSSION AND CONCLUSION

The analysis of the whole-class interaction demonstrates how this teacher made the class discussion a productive, collaborative learning experience by appropriating the affordances of the microblogging tool with an innovative educational task design, taking on role-playing to expand the ways in which he could teach historical reasoning. This means that the task design was central to how the microblogs became a structuring resource in the teacher–student interaction, and this relates to the way this teacher used dialogues to encourage students to articulate and reflect on their own understanding. As the analysis of the interactions show, these three elements are interwoven in practice, but for analytical purposes, we separate them in the following discussion.

First, as discussed, previous research has argued that technology can change, challenge and support school learning to develop skills and competencies in school subjects (Rasmussen & Ludvigsen, 2010). However, it is not easy to bridge the gap between the potential of technology and its productive use in the classroom. This case study of one teacher reveals how microblogging was used to create a shared learning space and opportunities for making 'thinking visible', for sharing the learning process and for supporting and achieving collaborative tasks (the jigsaw role-play task). It also shows that microblogs affect participation patterns in classrooms (Hsu et al., 2014; Mercier et al., 2015). Social media and Web 2.0 applications have a pervasive presence in students' lives inside and outside the classroom and it has been argued that they represent new forms of literacies that are needed in the 21st century, and that the learning processes taking place are less about accessing information and processing pre-scripted action and more about making sense of knowledge from a multitude of sources. Often, achieving such a complex accomplishment involves reaching beyond the boundaries of the pre-defined instructional process and the traditional sources of knowledge, to engage in sense-making processes that are more open ended and less structured. However, to account for the potential transformations (Puentedura, 2014) that microblogging in classrooms may have, further research is needed; an important contribution will be to examine how the 'ground rules' for classroom interaction are transformed through the inclusion of tools in the classroom that are explicitly designed to enable wider student inclusion in these interactions. Furthermore, the use of technology must be seen in connection with the social interaction and the social organisation of learning activities. In our case, it does not seem to be the microblogging per se that is most important, but the technology-mediated social practices that were supported.

Second, the teacher – student interaction (the collective group work) was in this case highly structured by the microblogs. Analysing the students' presentations, including their microblogs, we saw that they drew on a combination of comprehension strategies, such as reading aloud from the blogs and/or summarising them, and the elaboration and integration of the content presented (Perfetti et al., 2008). Importantly, the teacher called on the students to respond to each other, initiating student – student turns, which is reported to be less frequent in whole-class conversations (Alexander, 2008; Lawrence & Snow, 2011). In addition, the teacher's open-ended questions helped the students to provide reasons for their country's position on nationalism (Mercer & Littleton, 2007). It is clear that oral discussion is crucial as a facilitator of students' acquisition of specific strategies (Lawrence & Snow, 2010). However, as mentioned, the studies on classroom discussion did not initially emphasise forms of oral discourse as essential in changing how we think – in creating a context for learning. The context that was created in this classroom provided the students with a frame for trying out their knowledge and it was through interactions with the teacher and with peers that the microblog content gained historical significance for the students. The teachers encouraged and participated in subject talk/professional discourses, providing students with a strategy for engaging the (re)sources as historians. As such, the illustration shows how dependent the students' sense making becomes on the social interaction with their teacher and their peers to use the sources in the way that is expected in history as it is taught in school today. The task design (jigsaw and role-play) also highlighted the cognitive effort of shifting perspectives, both between countries and to another time and place (the beginning of the 20th century). This form of historical reasoning often remains implicit and opaque for students. The analysis unpacks the kind of work that the teacher does – the instructional support that he provides.

Third, the idea that the discussion of different perspectives or contradictory ideas is beneficial for learning is supported. The teacher's task design supported this. From our results, discussions moderated and fostered by teachers drew attention to central ideas that may not have otherwise surfaced. The jigsaw-inspired role-play tasks were an excellent way to bring forward the various views on nationalism as the students read the blogs and listened to each other's arguments. The teacher typically repeated, rephrased or referred to the microblogs that were on display (i.e. Hennessy & Warwick, 2010). As the host of the conference, he had designated himself the centre of the activity. In that role, it was also natural that he call on countries to comment on each other's contributions and by so doing assist the students in extending their contributions. The teacher integrated the microblogs, providing a shared learning space for the class and a collective focus of reference during the whole-class discussion. He used the blogs as a partner and participant to act and interact through to pursue the goals of the session. As we have seen from the examples, the students' microblogs provided a representation of the groups' collective thinking and, as a

product made visible, this was referred to and elaborated on in the collective whole-class discussion. The teacher read the statements aloud, commenting on the countries' concluding statements and adding issues or correcting what was missing. In other words, the technology provided the teacher with access to the students' reasoning, as displayed in notes on the whiteboard, enabling the teacher to employ well-known support techniques, as described by Mercer (2000):

- Elicit knowledge from student (microblogs and presentation).
- Respond to what students say (by repeating, reformulating, elaborating, connecting and expanding).
- Describing shared classroom experiences and meta-talk (closing comment: talk about the talk and the activity; pointing out the subject-specific character and the purpose of the activity).

The role-play provided an entry into exploring nationalism as a historical concept. The teacher started by modelling, through his use of language, how to apply the content in the jigsaw task and asked a series of open questions. As seen in the examples, the students picked up the teacher's way of using language and knowledge, and argued from their country's perspective. As the students said in the interviews, they gradually came to an emerging understanding that nationalism was not the same across the countries represented. This is an important precursor for developing a deeper understanding of the concept of nationalism, underlining how nation-states in Europe later evolved in so many different ways and with very different systems and ideologies within the framework of the nation-state (i.e. Ernest Gellner's theories).

Importantly, the evolving insight that there is more than one type of nationalism did not stem from one group or individual alone but emerged as the students took turns presenting their country's perspective and discussed the differences between the countries in the class. The well-known Aristotelian quote that 'The whole is greater than the sum of its parts' may be used to indicate the central finding of this study. This saying describes the synergy that exists between individuals working together in a joint effort. However, in our case, it is fair to conclude that this synergy would probably not surface in the same way without the careful dialogic orchestration conducted by the teacher, including his enacted task design and appropriation of microblogging.

ACKNOWLEDGEMENTS

I would especially like to thank the teacher, Magnus Sandberg, for years of productive collaboration and EngageLab, specifically, Ole Smordal, Jeremey Tossant and Richard Neiss, for the technological development of Socius and Talkwall|Samtavla. I would also like to thank Åste Hagen for fieldwork and Anniken Furberg for comments on drafts of this chapter.

NOTES

[1] https://en.wikipedia.org/wiki/Microblogging

[2] The application running on the iPad retrieved all the statements belonging to the nation from the server by querying the appropriate hash tag.

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5. TEACHER SUPPORT IN TECHNOLOGY-BASED SCIENCE LEARNING

Balancing Procedural and Conceptual Support in Students' Learning Processes

INTRODUCTION

This chapter focuses on the support provided by a teacher in a setting where primary school students worked on a technology-based science project. This setting involved open-ended tasks to be solved through project work, peer collaboration, and the use of various information resources. In today's schools, this type of instructional setting is quite common, which makes them interesting to study. From an early age, students are exposed to conceptual tasks that pose complex multidisciplinary problems, usually involving integration of relevant information by the use of multiple digital and non-digital resources. These types of learning activities, which encompass a high level of student engagement, are referred to as exploratory or inquiry-based activities. In naturalistic classroom settings, the teacher most often acts as an important resource and provides various forms of guidance during students' learning activities. Nevertheless, several researchers have pointed out that rather few studies focus on the role and significance of dialogue-based teacher support in technology-based learning settings. The underlying claim of the current study is that more knowledge is needed about the teacher's role in these types of settings. By taking a dialogic approach (Linell, 2009; Vygotsky, 1986), the study aims to further explore the role of teacher support in technology-based learning in science education by directing the analytical attention towards various forms of teacher support, and their potential roles in facilitating students' development of conceptual understanding.

Studies focusing on classroom dialogues have shown that various forms of teacher support are essential for students' development of conceptual understanding; in particular, two pivotal forms are *conceptual* and *procedural* support (Furberg, 2016; van Leeuwen, Janssen, Erkens, & Brekelmans, 2013).[1] Conceptual support refers to guidance by helping students make sense of the scientific content (i.e., the concepts or processes) associated with the scientific theme of the project, activity, or assignment. In other words, it involves conceptually oriented talk that directs the

E. Elstad (Ed.), Educational Technology and Polycontextual Bridging, 83–105.
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students' and the teacher's attention towards making sense of conceptual issues. As will be discussed in more detail in the review section, teachers may apply several strategies when providing conceptual support. Procedural support involves guidance by helping students regulate their work processes. For instance, this might involve aid in task planning, structuring their work process, finding relevant information, dividing labour between students, and regulating time. The teacher uses both forms to facilitate students' *development of conceptual understanding*. An underlying premise of this study is that the two support forms are to be seen as analytical concepts, implying that they do not necessarily exist as clear-cut entities. In everyday classroom dialogues, the teacher provides both conceptual and procedural support to the students, and often within the same dialogical sequence. The interesting point is to identify what can be seen as *patterns* in the teacher's way of supporting students, as well as how the teacher balances the forms of support within different activity forms of the technology-based science project.

The empirical basis for the current study is a science project about "health and the human body" involving fifth-grade primary school students (aged 10–11) and their teacher.[2] Central themes were the heart and lung functions and the blood circulation system. The learning activities involved a combination of whole-class activities, individual seatwork, and group work. The students used various digital information resources available through their personal iPads. In order to explore the complexity of facilitating students' development of conceptual understanding in these types of settings, we performed detailed analyses of selected student – teacher interactions taking place within the various learning activity settings. We directed the analytical attention towards student – teacher interactions within various activities because such interactions display the challenges experienced by the students as well as the teacher's responses to those challenges. The following research questions guided the analyses:

- *What types of student challenges emerge in the various settings?*
- *What types of support does the teacher provide within the various learning activities?*

Before we enter the empirical analysis section, we will present and discuss relevant findings from previous studies focusing on teacher support in computer-based learning settings. Subsequently, we will account for the underlying sociocultural perspective that forms the underlying premise for our view on teacher support, as well as the applied analytical procedures (Mercer, 2004; Säljö, 2010; Vygotsky, 1978). Then follows a section where we will outline and discuss methodological issues. The analysis section constitutes the hearth of the chapter, comprising detailed analyses of selected excerpts of student – teacher interactions taking place during the science project. The chapter will conclude with a discussion section addressing the empirical analyses in light of the findings from previous research.

STUDIES OF TEACHER SUPPORT IN COMPUTER-BASED SCIENCE LEARNING SETTINGS

Although many studies have documented positive sides of students' engagement in collaborative and inquiry-oriented learning activities involving the use of digital resources, studies have also found challenges in these learning settings. Some of these challenges concern *conceptual aspects* such as making sense of the concepts, problems, or assignments; making sense of and applying digital- and text-based conceptual resources; and engaging in productive conceptual sense-making dialogues with peers (Hmelo-Silver & Barrows, 2008; Mercer, 2004). Other challenges involve *procedural aspects* such as structuring their work process and tasks, practicing time management, and dealing with practical and social sides of peer collaboration (Engle & Conant, 2002; Furberg & Arnseth, 2009). The findings from studies focusing on students' learning processes in technology-supported learning settings provide compelling arguments for the need to explore teacher support in these types of settings. In the following, we present studies of teacher support organised according to their findings related to the significance of providing conceptual and procedural support.

Findings Related to the Significance of Conceptual Support

Several studies have emphasised the significance of student – teacher interactions in terms of providing conceptually oriented aid in computer-supported learning settings (Dolonen & Ludvigsen, 2012; Jornet & Roth, 2015; Mercer, 2004). Mercer and his colleagues studied classroom dialogues and their functions, both in class-wide and small-group settings (cf. Mercer, 2004; Mercer & Littleton, 2007). By analysing student – teacher interactions, Mercer (2004) identified the following central functions of communicative teacher intervention: elicitation of students' understanding, contextualisation and re-framing of students' verbal accounts, and conceptual re-phrasing of students' utterances through the application of more scientific terms. Classroom dialogue studies have also shown positive effects of conceptual understanding on students' development when the teacher provides indirect intervention, for instance by prompting metacognitive questions or encouraging students to retrieve science-based information instead of providing descriptive explanations or prompting fact-based student responses (Hakkarainen, Lipponen, & Järvelä, 2002; Hmelo-Silver & Barrows, 2008).

Studies of student – teacher dialogues have also offered insight into how digital tools can be used as resources in conceptually oriented classroom discussions (Mercer, Hennessy, & Warwick, 2010; Rasmussen & Hagen, 2015). Gillen, Littleton, Twiner, Staarman, and Mercer (2008) demonstrated how teachers used interactive whiteboards in primary science education as instructional resources

for facilitating students' development of conceptual understanding. In one of the study's analysed cases, a teacher used the multimodal possibilities of an interactive whiteboard to introduce the students to the phenomenon of evaporation. By using self-produced video clips and video stills to demonstrate how water evaporates in a hot frying pan, the teacher invited the students into a discussion of the process taking place. The analyses of student – teacher interactions showed that the multimodal presentation created continuity between lessons, established shared experience and understanding, and bridged the gap between everyday and scientific explanations of scientific principles.

Findings Related to the Significance of Procedural Support

Concerning the types of support provided by teachers, one of the studies within the SMUL-project mapped different types of teacher interventions in Norwegian classrooms across different types of subjects (Hodgson, Rønning, & Tomlinson, 2012). The systematic observations revealed that the most frequent teacher interventions concerned supervision and follow-up of students' work processes, i.e. forms of procedural support. A case study by Furberg focusing on teacher support in a computer-based science project (Furberg, 2016) further documented the emphasis on and significance of procedural support. Analyses of students' help requests to the teacher during group work showed that 29% of all help requests concerned procedural aspects of their work. Furthermore, guiding students in how to practically plan and carry out the inquiry work became essential support for the students to understand not only the concepts at issue, but also the notion of doing inquiry.

Support aimed at helping students to regulate their working processes has proven to be particularly important in learning situations characterised by exploratory work and student collaboration (Howe et al., 2007; Mäkitalo-Siegl, Kohnle, & Fischer, 2011; Strømme & Furberg, 2015; Urhahne, Schanze, Bell, Mansfield, & Holmes, 2010). One important aspect of procedural support is to help students become self-regulated, and thus be able to regulate and organise their own learning processes and activities in individual as well as in collaborative learning situations (Järvelä, Järvenoja, Malmberg, & Hadwin, 2013). Studies have frequently revealed that students find it challenging to plan, organise work tasks, administrate time use, and locate relevant information resources. This especially applies to experimental learning settings (Lunetta, Hofstein, & Clough, 2007) as well as inquiry-oriented learning settings, which often stretch over time and involve open-ended, unstructured tasks (Urhahne et al., 2010).

In a setting of computer-supported collaborative inquiry learning within physics, Mäkitalo-Siegl et al. (2011) examined the influence of consolidation-oriented teacher support in whole-class settings. In one classroom condition, the teacher provided instructions for consolidation at the beginning of each new inquiry phase in a plenary session. The teacher also evaluated and discussed the results with the students at the end of each inquiry phase. In the other classroom condition, the teacher did not

interrupt small-group collaborations with instructions or provide evaluations in a plenary session. Analyses of the students' dialogues during their work processes showed that the students in the first condition sought less help during group-work activities, but showed higher learning gains than students in the condition with lower teacher intervention (Mäkitalo-Siegl et al., 2011).

The review of the studies focusing on various forms of teacher support in collaborative, technology-based learning settings offers a valuable background for understanding the significance of both conceptual and procedural support as ways of helping students in their development of conceptual understanding. However, studies undertaken by Strømme and Furberg (2015) and Furberg (2016) focusing on student – teacher interactions during a computer-supported inquiry-based learning in the setting of science education show how difficult it can be for teachers to find the right balance between providing procedural and conceptual support. For instance, teachers experience difficulties finding the balance between providing the information requested by students and facilitating students in utilising resources and each other's knowledge and understanding.

In the current study, we analysed excerpts of student – teacher interactions taking place in technology-supported science in relation to the outlined conceptualisations of teacher support. Before discussing our analyses, we will provide a brief account of our underlying sociocultural perspective.

A SOCIOCULTURAL PERSPECTIVE ON TEACHER SUPPORT IN TECHNOLOGY-BASED LEARNING SETTINGS

From a sociocultural point of view, the notion of "helping" students in their learning processes is a central issue. This was especially highlighted in Vygotsky's (1978) concept of the "zone of proximal development," referring to the difference between what a learner can do with and without help from more experienced individuals. Vygotsky's concept reveals that help-seeking is not only desirable, but essential to the development of skills and conceptual understandings. An important part of human conduct and learning processes is the use of material tools (Säljö, 2010), which can be seen as cultural artifacts that store knowledge and social practices developed over generations (Cole, 1996). This interpretation implies that digital learning environments—often containing representations such as graphs, visualisation models, or simulations—display and represent experts' knowledge about objects, processes, or phenomena. Students interact with the knowledge and practices stored within digital learning environments when they utilise these representations in their learning activities (Säljö, 2010). In this sense, digital learning environments with their embedded digital tools are resources for promoting students' development of conceptual understanding.

Seen from a sociocultural perspective, learning is a dynamic, social, and interactive meaning-making process (Linell, 2009; Säljö, 2010). Through their interactions, participants try to interpret and make sense of situations, activities,

resources in use, and scientific concepts. Within this context, language is considered the most important tool for making sense of the world and for mediating thinking and reasoning (Vygotsky, 1986), with discourse serving as a "social mode of thinking" (Mercer, 2013). Making sense of scientific concepts is a dialogical matter that takes place among interacting participants in specific settings, including help-seeking settings in which students interact with teachers (Strømme & Furberg, 2015). Seeing learning as an attainment of shared meaning and understanding does not imply that students can develop just any interpretation of scientific concepts. Every scientific field encompasses a range of relevant terms and ideas, in addition to valid ways of talking about these matters. In educational settings, students perceive the teacher as an "expert" within specific knowledge domains and the main mediator of valid ways of discussing scientific concepts. The teacher is also a facilitator of prevailing valid methods of understanding assignments and solving assignments in a satisfactory manner (Jornet & Roth, 2015; Strømme & Furberg, 2015).

As previously mentioned, a sociocultural perspective forms the basis for choosing a dialogical approach when exploring support provided by a teacher in this study's empirical setting. The choice of a dialogical approach has consequences and implications for our research design, data, and analytical procedures, as accounted for in the following section.

METHODS

Participants and Educational Setting

The data were produced during a case study as part of the Ark&App project (Furberg, Dolonen, & Ingulfsen, 2015). The empirical setting was a science project about "health and the human body," which took place over the course of two weeks in March 2015. The participants were one class of 18 primary school students aged 10 to 11 years, and their science teacher. One of the strategic focuses of the school in focus was to enhance teachers' and students' digital competency. As a part of this strategy all students are provided with their personal iPad when they reach grade four. This implies that the students and the teacher in focus of this study were in their second year as frequent iPad users. In addition to the iPads, the classroom was equipped with an interactive whiteboard.

The project focused on the four general topics heart and lung functions, blood circulation, and CPR. Each thematic part in the project opened with a whole-class activity focusing on the learning goals and activation of students' prior knowledge, followed by individual activities where the students prepared their contributions to be used in collaborative group-work activities. Each thematic session ended with a whole-class activity involving consolidation and reflection on the undertaken tasks and concepts at issue. The teacher selected the themes and learning goals for the project, as well as planning the learning activities and use of learning resources. The teacher was not given any specific instructions from the researchers regarding her

role as a teacher in the project. During the project, the teacher was fully responsible for implementing the instructional design without inference from the observing researchers.

Data Material and Analytical Procedures

The main data material applied in the present study constituted 12 hours of transcribed video recordings of all student – teacher interactions taking place during the project, as well as transcriptions of interaction taking place within three student focus groups. Ethnographic field notes made during classroom observations provided supplementary contextual data for the analyses of the participants' interactions (Derry et al., 2010). Furthermore, resources and products developed by the teacher and the students such as PowerPoint presentations, week plans, project plans, and worksheets were collected. To ensure confidentiality, the participants' names have been anonymised on all materials.

For detailed analyses, we selected five interaction sequences in which the students' and teacher's attention was directed towards making sense of conceptual or task-related issues, in this case heart and lung function. To illustrate the challenges experienced by students within the various learning activities and the teacher's responses to those challenges, we selected one excerpt from the start-up activity, one excerpt from the individual activity, two excerpts from group-work settings, and one excerpt from the whole-class sum-up session. Each of these activities involved the use of various forms of digital resources. We selected the analysed excerpts based on three criteria. First, the chosen excerpts involved settings where the student – teacher interaction focused on talking about scientific concepts and how to complete the assignments. A second selection criterion was that the conceptual focus of the help requested and provided should reflect the *most frequent* conceptual challenges addressed. The third requirement concerned interactional transparency, such that the settings selected involved participants' talk characterised by a certain degree of verbal explicitness (Linell, 2009; Mercer, 2004). Based on these criteria, the selected settings displayed typical interactional patterns of the teacher's way of supporting students, as well as how the teacher balanced the two forms of support within this empirical setting.

The applied analytical procedure was interaction analysis, involving a sequential analysis of the talk and interaction between interlocutors (Jordan & Henderson, 1995). A sequential analysis implies that each utterance in a selected excerpt is considered in relation to the previous utterance in the ongoing interaction. As a result, the focus is not on the meaning of single utterances, but on how meaning is created within the exchange of utterances (Mercer, 2004). This practical guideline for analysis ensures that the participants' concerns and their actual activities—not only the researchers' intentions and predefined interests—are scrutinised (Linell, 2009). The video recordings were transcribed according to Jeffersonian transcription notations (Jefferson, 1984).[3] The discourse took place in Norwegian, and the

researchers translated the material. In addition to the detailed examination of the interaction sequences, ethnographic information about the institutional setting was used as a background resource for understanding what was going on.

ANALYSIS OF TEACHER SUPPORT IN A TECHNOLOGY-BASED SCIENCE PROJECT

Some of the most prominent features in this case are the clear and structured instruction and class management that the teacher demonstrated throughout the project. The students were seated in groups of four to five students, and each student had an iPad. The teacher dedicated two to three 45-minute school lessons to each of the four thematic sessions. All thematic sessions were designed in a similar manner, opening with a whole-class activity where the teacher presented the learning goals, activities, assignments, and relevant resources. Then followed a more dialogically oriented sequence where the teacher typically explored the students' prior knowledge of the topic in the coming session. During whole-class activities, the teacher frequently used the interactive whiteboard as a resource.

After the whole-class setting followed a working session starting with an individual activity, which continued into a collaborative group-work activity. The teacher often organised the individual/group-work activities according to a "jigsaw design" (Aronson, Bridgeman, & Geffner, 1978; Brown et al., 1993). The idea behind the jigsaw design is to organise classroom activity that makes students dependent on each other's input to succeed. In this setting, the jigsaw design required students first to work individually to prepare themselves for group work, for instance by reading a designated text, exploring digital representations such as a simulation or a model of the blood circulation, or listening to a text reading. Then followed a group-work activity where the students, based on their notes, explained to their peers what they had learned. Based on their peers' explanations, the listeners were to add new notes to their own. During the individual and group-based activities, the students used their iPads and other digital resources provided by the teacher. Each thematic session ended with a whole-class sum-up activity focused on conceptual recap and reflection. These sessions typically had a dialogic form involving teacher-led discussions. As in opening whole-class activities, the teacher frequently used the interactive whiteboard as a resource during discussions. In the following, we will present and analyse selected excerpts from each of the four activity settings.

Setting 1: Teacher Support in Whole-Class Opening Sessions

Excerpt 1 is from the whole-class introduction setting at the very opening of the project. Prior to the excerpt, the teacher presented the learning goals of the day's lessons, learning activities, and the designated digital and paper-based learning resources. After providing the information, she initiates a whole-class activity where the students are to construct and submit questions about issues that they would like

to explore during the project. Using their iPads, the students submit their questions through the web-based group tool Padlet, which enables single users to write notes, comments, or questions on a computer or an iPad, and share them on a workspace for common reflection. Excerpt 1 opens with the teacher instructing the students on how to log in to the common workspace she created in Padlet:

Excerpt 1

1. Teacher: The address is displayed in red (*referring to the link appearing on a hand out*). Once you've entered you can start submitting your questions on the whiteboard. You are allowed to write more than one question
(*the students start writing up question on their iPads*)
2. Teacher: (*opens the web-page so that it appears on the interactive whiteboard*) It's starting to pop up questions
(*students are writing questions individually*)
3. Teacher: So, I want everybody to press "refresh" on your iPad. Then you will see all the questions. […]. Now, I want you to look for a question, which is not yours, which you find interesting
(3) (*several students rise their hand*)
4. Teacher: Eric. Is there a question that you find interesting?
5. Eric: How can the blood vessels fit in our body when they are as long as two times around the Earth? (*quoting a question on the board*)
6. Teacher: Yes. Good question. Two times around the Earth. Hum, that's pretty long. John?
7. John: How many times does the heart of a new-born child beat per minute?
8. Teacher: Does it beat slower? Does it beat faster? Yes, maybe we'll learn about that

Examining these activities in the thematic opening sessions in terms of conceptual and procedural support, we assert that the teacher provided both types of support. As described above, she consistently opened by introducing the session's learning goals, activities, and resources. The interaction taking place in Excerpt 1 shows how she also provided conceptual support in the opening sessions. The selected activity was aimed at identifying the students' prior understanding of the topic by using the students' questions as a starting point. At this point, the teacher avoided answering the students' conceptually oriented questions. Instead, she confined herself to confirming the relevance of the specific questions, as well as elaborating on some of them, as seen in line 8. By refraining from commenting

and elaboration on the students' questions, the teacher provided limited, if any, conceptual support. However, another way of viewing the support provided in this setting is to recognise that her use of Padlet offered conceptual support in this setting: By displaying the students' questions on the interactive whiteboard, she turned the students' individual conceptual contributions into a collective endeavour. Likewise, she enforced the collective aspect by instructing the students to engage with each other's ideas. In other words, she provided conceptual support by investigating the students' prior knowledge (making their prior knowledge visible for all students) and thereby guiding the students' conceptual attention. Importantly, she also tried to, and seemingly succeeded in, encouraging the students' academic curiosity.

Setting 2: Teacher Support in Individual Activities

During individual work, the students engaged with assignments prepared by the teacher. In these settings, the students frequently used their iPads, sometimes in combination with a notebook or worksheets. Key learning resources were digital articles and texts about the heart and lung functions and blood circulation developed by textbook publishers or commercial educational-oriented organisations. Most of the resources also comprised visual representations such as simulations, animations, models, and images. To illustrate some typical aspects of teacher support during individual activities, we have selected an excerpt from a session where the students were to monitor whether they had reached the learning goals the teacher presented during the opening of the project. The session took place in the third of the four thematic sessions in the project. In the opening of the individual activity, the teacher gave the students a handout listing detailed conceptual learning goals for each of the thematic areas that the students had explored. The teacher instructed the students to use their textbook or the designated digital resources.

In Excerpt 2, we enter a setting where Carrie summons the teacher for assistance. She is grappling with the question, "Do you know why you have a transportation system in your body?"

Excerpt 2

1. Teacher: Yes? (*approaches Carrie*)
2. Carrie: The text didn't say <u>anything</u> (*points at her textbook*)
3. Teacher: About?
4. Carrie: <u>That</u> (*points at a question "Do you know why you have a transportation system in your body?"*) It didn't say anything
5. Teacher: No, but what do you think? Why do we have blood vessels?
6. Carrie: To <u>live</u>

7. Teacher: Yes, but what do they do? What does it say? (*nods in the direction of the textbook*)
8. Carrie: They carry things around in the body
9. Teacher: Uhum. What are they carrying?
10. Carrie: Carbo::n=
11. Teacher: Look in the text (*points at the text in the textbook*). Then you'll understand (*moves on*)

In this project, as also in this particular setting, the teacher had put a lot of effort into finding relevant information, both presented in textbooks and digital resources, to be used as conceptual support for the students. An important aspect displayed in Excerpt 2 is that the resources do not always provide enough conceptual support for the students, resulting in their asking the teacher for assistance, as Carrie does in Excerpt 2. It seems like her trouble with understanding the question about the transportation system is that she does not see the link between the terms "transportation system" and "blood circulation" (lines 2 and 4). Turning the focus towards the support provided by the teacher in this setting, the analysis shows that the teacher provided both conceptual and procedural support. Concerning conceptual support, the teacher provides this type of support by eliciting the student's understanding through probing cued scientific questions, as well as helping Carrie to see the link between the two terms (lines 5, 7, and 9). However, as we see, she refrains from providing explanations or elaborations on the questions and concepts addressed by the student, and neither does she follow the student into the text-based and visual resources. Instead, she changes her strategy to providing procedural support in instructing Carrie to revisit the textbook (line 11).

The change in support strategy might indicate that the teacher at this point assumed that Carrie was able to find the information she needed in order to answer the question. Another way of putting this is that the teacher in this setting re-established the information resources as the primary conceptual support, as well as substantiating the notion of helping students become independent and self-regulated learners. Nevertheless, it is also possible to see that the choice to provide procedural support may be a missed opportunity for engaging in conceptually oriented dialogues with a student by, for instance, using the textual and visual resources as a starting point. This also constitutes a missed opportunity for making sure that the student has developed a sufficient understanding of the concepts at issue. As the two following excerpts will show, the concept of the blood circulation system turned out to be a difficult matter for the students.

Setting 3: Teacher Support in Group-Work Activity

In order to display typical aspects of teacher support within settings where students worked collaboratively in group-work settings, we have selected two excerpts

from a jigsaw activity focusing on blood circulation. As described earlier, a jigsaw activity opens with an individual activity where the students are to prepare for their subsequent group work by reading designated digital texts accessed on their iPads, in this setting texts about blood circulation. The teacher provided all students within a group with different digital texts about the same issue. The jigsaw activity typically ended with a collaborative group-work setting where the students were to share and discuss the notes they made while reading the designated texts.

In the following, we start by presenting two excerpts from a collaborative group activity. Excerpt 3a) is from a setting where the student groups work on their own without the presence of the teacher. The students John, Ola, Linda, and Carrie take turns explaining what they have read. We enter when John, the final student to present, explains about the difference between the small and the large blood circulation system:

Excerpt 3a)

1. John: (*reads from his notes written down on his iPad*) When the heart pumps blood to the lungs and back it is called "the small circulation loop". When the heart pumps blood from the heart to the whole body it is called "the large circulation loop"
2. Ola: Wait (*making notes on his iPad*) Circulation loop (*writes with one hand*) Large?
3. Linda: Circulation loop? (*making notes on her iPad*)
4. Ola: C i r c u l a t i o n l o o p (*spelling aloud*)
5. Linda: I wrote (.) I just wrote the large and small circulation loop
6. John: (*pauses while he waits for the others finishing their writing*)
7. Carrie: l o o p (*writing on her notebook*)
8. John: The largest vein is called aorta
9. Ola: A o?
10. John: It's an important part for, uhm
11. Linda: Aoto? (*writes on her iPad*)
12. Ola: Aorta? (*looks at John*)
13. John: Yes

The interaction taking place in Excerpt 3a) displays that the students experience conceptual challenges on various levels: First, they struggle to spell and pronounce concepts such as *circulation* and *aorta*. Perhaps more importantly, they struggle to understand the meaning of concepts related to the functioning of the heart. All

these concepts are complex, and most students encounter these concepts for the first time at this level in the curriculum. Consequently, it is not surprising that the group struggles to understand and apply the concepts in this setting. However, how the students handle challenging concepts is noteworthy. As we observe from the excerpt, the students respond primarily by orienting themselves towards how the concepts are spelled and pronounced. They also use each other's explanations to rectify their own mistakes (such as Linda in line 5). Nevertheless, the excerpt shows that the students make little use of each other to provide or request clarifications, explanations, or visual illustrations that could support them in gaining a deeper conceptual understanding. In other words, the students support each other conceptually, but mainly in terms of spelling and pronouncing complex concepts, and to a lesser extent by elaborating and explaining scientific concepts and processes.

The episode represented in Excerpt 3b) takes place only a few minutes later. John is still sharing his information with the group, and he is here trying to describe the difference between arteries and veins. While explaining, he shows an illustration of the heart function found in an article from a website provided by the teacher. On the illustration, the arteries are highlighted in red and the veins in blue. We enter when the teacher approaches the group to check on how they are doing. She stands quietly beside John and listens to his presentation:

Excerpt 3b)

1. John: (*shows the illustration of the blood circulation on his iPad*). I think that the bronchi separate carbon dioxide and oxygen, and the red blood vessels, in a way, those with red blood cells that provide oxygen are called arteies (*the correct term would be* "*arteries*"). And I don't remember what the blue ones are called. It didn't say
2. Teacher: (*standing beside John and listens*) Uhum. We say arteries (*looks at John*). But it's not strange that you pronounce it like that because that's the way it's written
3. Carrie: Arte:ries?
4. Teacher: Arteries, yes
5. Linda: John has different facts
6. John: Yes, I had a lot of strange text. I didn't understand anything of what you had (*refers to his peers*), so I had to take a lot of notes
7. Teacher: Yes
8. Ola: What did you have, then? (*looks at John*)

9. Teacher: (*addressing Ola*) There are different texts, right? (*addressing John*) You had the TV2 text, right?

10. John: Uhum

11. Teacher: That one is difficult. That's probably the most difficult text of them all. I agree (*moves on*)

The opening of the excerpt shows John's explanation of the small and the large circulation (line 1). While explaining, he uses several complex scientific terms such as *bronchi*, *carbon dioxide*, and *oxygen*. He has difficulty pronouncing the term *arteries*. The teacher, who was standing quietly in the background, intervenes and pronounces the term correctly (line 2). Linda points out that John's text is different, and that he provided different facts than the rest of them. John agrees, but adds that he needed to make a lot of notes when the others presented their facts as he found it hard to understand their input. He describes his own text as being very "strange" (line 6). The teacher responds by explaining that the students were designated to read different texts, and that John had a particularly difficult text. Then she leaves, and approaches another group.

The interaction taking place in Excerpt 3b) highlights that the students experienced some conceptual challenges with the designated resources, as well as when listening to each other's explanations of the texts they had been reading. Their challenges concerned the pronunciation of scientific terms as well as grappling with their meaning. John used both his notes and a visual illustration of the article as resources while explaining what he had read; in doing so, he provided both visual and textual support for his peers. Despite his efforts, the students still struggled to understand some of the key concepts presented in the text. When the teacher approached them, the students expressed their confusion. Upon hearing the students' struggle to pronounce one of the terms correctly, the teacher intervened by providing a correct pronunciation (lines 2 and 4). Concerning the students' expressed difficulty in understanding each other's texts, as well as their comment on the differences between John's text and the other texts, the teacher responded by picking up on their comments on the differences between the texts. She did not, however, pursue the students' expressed challenge of understanding concepts and issues provided in the students' (in this case, John's) explanation. In a sense, it is possible to say that the students' expressed conceptually related challenge could be seen as an opportunity for the teacher to provide conceptual support, for instance by going deeper into how the concepts and processes are interrelated. Furthermore, the students' focus on a visual representation of cardiovascular system also offered the possibility of using the visual representation as a resource in order to explain and elaborate elements that the students struggled to understand.

Examining Excerpts 3a and 3b together reveals that the students experienced some conceptual challenges. As she did in the individual activity (Excerpt 2), the teacher provided what can be seen as a minimum of conceptual support so that the students

could carry on with their work. However, in doing so, the teacher handed over the responsibility for the conceptual sense-making work and their engagement with the learning resources to the students. If we were to understand the teacher's way of supporting the students only from the analyses of student – teacher interactions taking place during individual and group activities, it would seem like the teacher oriented towards providing primarily procedural support, and less conceptually oriented support. A closer look at the dialogues taking place in whole-class sum-up activities, however, shows that this was not the case.

Setting 4: Teacher Support in Whole-Class Sum-up Activity

Excerpt 4 is from the sum-up session taking place towards the end of the previously analysed group-work activity. The teacher gets the students' attention, and opens the shared workspace in Padlet on the interactive whiteboard displaying the questions formulated by the students at the very beginning of the project. She asks the students to reflect on the questions:

Excerpt 4)

1. Teacher: Raise your hand. Are there any questions you still wonder about? (2.0) I hope so because science is really about finding new questions. (2) That's science, and I don't think we've found the answers to all our questions. Annie?
2. Annie: Why doesn't the heart stop when we hold our breath?
3. Teacher: Uhm. Yes. We haven't found an answer to that one. Is there anyone that has an answer to that? John?
4. John: I'm not really a 100% sure but since – As long as we hold our breath the heart will continue to beat until we pass out. So, if the heart doesn't pump, the muscles won't get the nutrition they need. And then you'll pass out
5. Teacher: Uhum. We have learned about breathing. We've learned that breathing and heartrate are not completely related but they do cooperate. They are not the same. So breathing is not the same as the heartrate. As John correctly said; they are related in the sense that if we don't get air into the lungs then the heart will stop beating. Because it's dependent on the cooperation with the lungs. They are not the same but they collaborate. Will?
6. Will: How many blood vessels are there in the body?
7. Teacher: Yes. We didn't exactly find an answer to that, but we do know how long they are. Linda?
8. Linda: A hundred thousand kilometres

9. Teacher: Yes. Or said in a way that makes it easier to understand? Roger?
10. Roger: Two times around the earth
11. Teacher: Yes. Think about that. Someone said earlier that they don't look that long in the textbook. I understand, but then there are all those tiny blood vessels that go into the tips of my fingers that make me freeze when it's cold. They are not displayed in illustrations, but we have to count them in as well

There are aspects of the interaction taking place in Excerpt 4 that we would like to emphasise. The first aspect concerns the teacher's way of providing support in sum-up sessions. In sum-up sessions, as exemplified by Excerpt 4, the whole-class dialogues were mostly teacher-led dialogues where the teacher often invited the students to share their ideas, questions, or comments. She engaged in the dialogue by validating and elaborating on the students' responses (lines 5, 7, 9, and 11). Furthermore, she prepared the ground for letting the students provide conceptual elaborations and explanations to each other's questions and ideas (lines 3, 7, and 9). Subsequently, she picked up on the students' responses by confirming (lines 5, 9, and 11), re-voicing (line 5), applying the correct scientific terms (line 5), and linking related bodily terms and processes (lines 5 and 11). Thus, it is possible to see that the teacher provided a huge amount of conceptual *and* procedural support when facilitating the classroom dialogues in the sum-up sessions.

The second aspect we would like to emphasise concerns the support functions of the interactive whiteboard and Padlet. The interactive whiteboard was a shared object that both students and their teacher oriented towards as we also observed in the analysis of Excerpt 1. In that setting, the shared workspace in Padlet became a resource for the teacher when eliciting the students' prior knowledge by asking them to post questions they were wondering about. In the sum-up session, however, the interactive whiteboard and the questions posted on their shared workspace became an important procedural support by constituting a shared starting point for the classroom dialogue. In addition, they offered support in organising the students' conceptual attention and input. All in all, the analysis of the student – teacher interactions taking place in the whole-class sum-up setting shows the significant role these learning activities had in this project. The teacher used these settings to provide conceptual support and to respond to and elaborate on some of the concepts addressed by the students during the individual and group-based activities. It was in these situations that the relationships between the scientific concepts were explicitly addressed and made visible to the students.

DISCUSSION

In the following, we will open by highlighting some of the key empirical findings from the analysis of the student – teacher interactions within the various learning

activities, seen in relation to the two overall research questions focused on the conceptual challenges experienced by the students and the type of support provided by the teacher. Subsequently, we will discuss the empirical findings in light of previously undertaken research. This comparison reveals two issues we will elaborate on, namely the support provided in dialogic whole-class settings and the support provided in individual and group activity settings.

The first issue is *the support provided in dialogic whole-class settings*. Several studies have shown that whole-class dialogues facilitated by a teacher are important resources in students' learning processes (Engle & Conant, 2002; Mercer, 2004). This study's empirical findings were in line with previous research. In particular, the analyses of the interaction taking place within the two whole-class settings showed the importance of student – teacher dialogues in terms of facilitating students' development of conceptual understanding. The teacher invited the students to pinpoint questions that they still wondered about, as well as inviting them to elaborate and provide explanations to each other's questions. Then, she engaged in the dialogue by providing re-formulations, applying the correct scientific terms, and re-framing the students' contributions into a larger scientific context. In the whole-class sessions, the teacher also used the dialogues to ask more open-ended questions as well as more meta-cognitive questions aimed at reflecting on the students' conceptual understanding. These types of meta-cognitive questions have proved to be of high importance for students' development of conceptual understanding (Hmelo-Silver & Barrows, 2008).

A second aspect of the whole-class dialogues concerns the teacher's effort of creating *shared* conceptual sense-making processes. She did this by inviting the students to build on their individual contributions and by letting the students comment on each other's questions. Creating such shared spaces for collective reasoning has proved to be of vital importance for students' development of conceptual understanding (Hmelo-Silver & Barrows, 2008; Mercer & Littleton, 2007).

A third aspect of the dialogues taking place in whole-class settings can be seen in relation to Linn and Eylon's (2011) assertion that an important part of science learning is making scientific ideas and understanding visible to others through dialogues. Along with the productive side of explicating one's understanding or misunderstanding, such dialogues also constitute an opportunity for a teacher to get insight into the students' prior knowledge, what they find hard to understand, or ideas that are in conflict with ideas held by experts in the field. The analyses of the sum-up whole-class settings showed that the teacher exploited these dialogical opportunities in the whole-class settings.

The final facet of the whole-class dialogues concerns the role of the technology in use, namely the shared workspace displaying the students' individual questions. Findings from interactive whiteboard studies have shown how digital representations can serve as productive resources in classroom settings (Gillen et al., 2008; Rasmussen & Hagen, 2015). This was also demonstrated in the current study, when the teacher used the students' questions displayed on the interactive whiteboard to

turn the students' individual conceptual contributions into a collective endeavour and engage the students in collective thinking.

In addition to these findings concerning support in whole-class settings, we must also examine *the support provided in the individual and group activity settings*. Our analyses of the interactions taking place within these two settings revealed that the students' conceptual challenges came to the surface. Previous studies have documented the advantages of peer collaboration in enhancing student learning. For instance, several studies have found that peer collaboration helps students develop scientific argumentation skills (Linn & Eylon, 2011; Mercer & Littleton, 2007), conceptual understanding (Furberg & Ludvigsen, 2008; Howe et al., 2007; Linn & Eylon, 2011), inquiry learning skills (van Joolingen, de Jong, & Dimitrakopoulout, 2007), and productive disciplinary engagement (Engle & Conant, 2002). However, studies have also illuminated the challenging aspects of peer collaboration—for instance, that students rarely engage in discussions characterised by "constructive listening" (van de Sande & Greeno, 2012) or "exploratory talk" (Mercer, 2004), and that collaboration as an activity is difficult for students (Furberg & Arnseth, 2009; Strømme & Furberg, 2015). Our analyses of the interaction taking place within the group-work settings likewise uncovered both positive and more challenging sides of these types of settings. On the positive side, the analyses showed that the students participated with a high level of engagement and motivation in the settings where they were to share their experiences and thoughts with their peers. However, it was also evident that they experienced some conceptual challenges in these settings, as well as struggling to engage in "exploratory talk" (Mercer & Littleton, 2007), or talk where the individuals engage critically but constructively in each other's ideas, and where claims and counter-claims are followed by justifications and explanations.

The challenges that the students experienced in the group-work activity can also be seen in light of the instructional jigsaw design. Several studies have scrutinised productive sides of an instructional jigsaw design facilitating students' construction and sharing of scientific arguments (Aronson et al., 1978; Brown et al., 1993; Karacop & Doymus, 2013). However, some studies have reported the more challenging aspects of jigsaw designs (Souvignier & Kronenberger, 2007; Strømme & Furberg, 2015). The current study yielded conflicting findings. On the productive side, the jigsaw design urged the students to present and listen to each other's presentations, as well as making them contribute with different information that expanded their individual contribution. However, as discussed above, the analysis showed that the students grappled with making sense of some of the scientific terms and concepts; furthermore, they did not engage in exploratory-oriented discussions in this setting. The study conducted by Strømme and Furberg (2015) substantiated the same challenge and pointed out that students may rarely challenge their peers to clarify or explain ideas because the concepts are so complex that it becomes difficult for the students to ask good questions or to elaborate. In addition, the study showed the

difficulty students might encounter with taking on the role as a scientific "expert" amongst peers, a role most commonly reserved for the teacher (Strømme & Furberg, 2015).

Overall, the more challenging aspects of the individual and group-based activities highlight the importance of both procedural and conceptual support provided by a teacher in these types of settings. In particular, procedural support may include the facilitation of student dialogues enabling students to participate critically and constructively in peer discussions, to elicit and explore each other's ideas, and to settle disagreements. These skills need to be cultivated over time, and research has shown the value of training students to participate in scientific discourse combined with introducing discussion ground rules (Mercer, 2004). Concerning conceptual support, the analyses showed the students' need for such support in both individual and group-based activities where they engage with various forms learning resources. The teacher can provide conceptual support by eliciting students' ideas and areas of confusion, as well as by elaborating, explaining, linking ideas and contextualising. Studies have shown that these types of support are of pivotal importance, also in settings where students engage with technology-supported activities and peer collaboration (Furberg, 2016; Strømme & Furberg, 2015).

It is also worth mentioning the potential of using digital representations as a focus of student – teacher interactions in these types of settings. In the study settings, the students engaged with a whole set of visual representations such as simulations, animations, and illustrations. Many studies have emphasised the potential of using digital representations as resources in conceptually oriented student – teacher dialogues (Furberg, 2016; Gillen et al., 2008). However, our analyses revealed that the digital resources in themselves did not provide enough conceptual support for the students. Consequently, this study illuminates the importance of teacher support in facilitating the students' engagement with the concepts, terms, and processes introduced by such resources.

CONCLUDING REMARKS

As the chapter comes to a close, we want to return to the relationship between conceptual and procedural support. The current study demonstrates the pivotal role of both procedural and conceptual support for students' development of both conceptual comprehension and their understanding of the procedures of doing exploratory and inquiry-related work in science. The findings also illuminate some of the challenges that the teacher might encounter in facilitating students' learning processes in these types of settings. The teacher constantly needs to balance and determine when and how to provide procedural and conceptual support. When considering the activities as a unit, we assert that the teacher balanced her procedural and conceptual support by emphasising different types of support in each activity. While the analyses of the individual and group activities showed that the students struggled and might have

benefitted from more conceptual support from the teacher, this balancing act is a difficult one to master.

A teacher's balancing of procedural and conceptual support is always a matter of providing students too much or too little support. On the one hand, it is possible to point at the untapped potential of the student – teacher dialogues taking place in the individual and group-work settings; in particular, these dialogic settings could have offered opportunities for the teacher to engage with the students' ideas and misunderstandings, and to develop shared conceptual understanding. On the other hand, one very important aspect of instruction is to support students in becoming self-regulated and capable of organising their own learning processes and activities in individual as well as in collaborative learning situations. In the end, teachers must continuously adjust their balance between these positions to engage their students and support them in meeting their full potential.

ACKNOWLEDGEMENTS

We would like to thank our colleagues in the Ark&App project, especially Øystein Gilje, Ingvill Rasmussen, Sten Ludvigsen, and Line Ingulfsen for their comments on earlier drafts. Special thanks are extended to the teacher and the students involved in the empirical study. Line Ingulfsen has also contributed in collecting the data material that this chapter builds on. The study was conducted in the context of the Ark&App project funded by the Norwegian Directorate for Education and Training, Department of Education and Department of Teacher Education and School Research, University of Oslo.

NOTES

[1] van Leeuwen et al.'s (2013) use of the term "cognitive activities" corresponds with the term *conceptual support*, and their term "cognitive regulation" corresponds with *procedural support*.

[2] The science project constituted one of 12 case studies performed in the Project Ark&App (2013–2016). See Furberg, Dolonen, and Ingulfsen (2015) for more details about the case study (http://www.uv.uio.no/iped/forskning/prosjekter/ark-app/).

[3] Transcript conventions:

=	Break and subsequent continuation of a single utterance
(# of seconds)	The time, in seconds, of a pause in speech
(.)	A brief pause, usually less than 0.2 seconds
.	Falling pitch or intonation
?	Rising pitch or intonation
!-	An abrupt halt or interruption in utterance
Underline	Emphasized or stressed speech
((*italic text*))	Annotation of non-verbal activity

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ANDERS KLUGE

6. BRIDGING IN MATHEMATICS

Learning Algebra by Using Games in School

INTRODUCTION

Playing computer games is an important part of the life of most Norwegian children and teenagers. 94% of children aged 9–16 report playing games during their leisure time. The average time spent (including non-gamers) is 108 minutes a day. Boys play, on average, almost twice as much as girls.[1] One of the conclusions of this computer gaming study from the Norwegian Media Authority is 'Almost all children have games as a hobby'.

It is fascinating to observe children and teenagers' intensity and skills during a session of gaming. They maintain focus over a considerable period of time and exercise what seems to be complete control over complicated environments, instruments and actors. To leverage this, researchers and teachers have studied gameplay and have set up experiments to explore how the engagement and obviously effective learning processes proceeding from students' high gaming skill level can be transferred to schooling (see e.g. Clark et al., 2016). Efforts have been made to design and develop games for learning, (often called 'sn erious games'), to turn gaming activities into learning processes that can be relevant outside of the gaming world (see e.g. Habgood & Ainsworth, 2011).

The massive proliferation of computer technology has paved the way for digital games and other digital representations, and this proliferation has been a strong force for change in school. In Norwegian upper secondary schools, every student gets a laptop when they begin their three-year education. Technology use and investment are also increasing in primary and lower secondary schools (Hatlevik et al., 2013); for instance, several Norwegian municipalities have experimented with the use of tablets, rather than paper and pencil, as the pupils' initial tool for learning how to write.[2]

Digital skills are also being incorporated into the curricula of the school system. Since 2005, digital competence (and 'digital skills') has become an integral part of what students are obliged to learn in Norwegian schools. Digital skills are defined as a basic part of education as it is described in the policy documents issued by the government, together with reading, oral skills, writing and calculation. This implies that practicing computer skills is mandatory, as is the case with the four other basic skills.

E. Elstad (Ed.), Educational Technology and Polycontextual Bridging, 107–127.
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School is a reflection of society. The gradual transformation of school, as it is impacted by the technological dynamics of society, is a more subtle and profound change than can be seen by studying documents produced by education authorities. Technological proliferation has led to dramatic changes on the individual, organisational, and societal level. This has consequences for school, as the institution prepares its pupils for their future and their working life as citizens, and supports their general human development. As technology drives change, the very basis of what is considered relevant knowledge also changes (Ludvigsen, 2012), with a deep impact on school over time.

Many of the traditional skills and competencies to be practiced, taught and learned in school are challenged by digital technology, such as handwriting, calculation, learning facts, span of concentration and even reading larger chunks of text (Ananiadou & Claro, 2009). This development places the school in tension between the curricula and the pressure from a changing society (NOU, 2014:7), where the game-world where most children spend hours every day plays a part.

In this situation, Norwegian schools have experimented with using serious games for learning; in this chapter, algebra is the subject of game-based learning. International surveys have repeatedly shown that Norwegian pupils are generally weak in algebra, compared to other high-GDP countries. Results from mathematics in general in Norway are around average next to comparable countries, but algebra stands out as an area in which Norwegian pupils are weak. This can be seen in the TIMSS studies from grade 8, compared to the other three mathematical areas (numbers, statistics and geometry) and compared to the other countries in the survey.[3]

Based on this data, the project Ark&app[4] have selected algebra as a subject for study and investigation at three levels in Norwegian schools: grade 5, grade 8 and the first grade of upper secondary school. Games were used for the investigations in grades 5 and 8, and this portion of the study forms the empirical basis of this chapter. From the perspective of bridging, we study how elements of the students' life-world outside of school—in this case the use of digital games—are transferred to a school context. This chapter seeks to answer the question of whether the productive learning processes happening in the pupils' leisure time can be transferred to the school context and be productive for curricular learning.

An important issue regarding the use of serious games in school is how it can promote activity. Active learning includes physical, cognitive and verbal activity, and is an important part of most contemporary learning schemes (Linn & Eylon, 2011) as a desired way of learning (Chi & Wylie, 2014). Activity and engagement will, consequently, be an important part of this study. We will also study the relevance of learning processes. From observational studies, it is clear that gamers can reach a high level of proficiency within the framework of the game, but an important question for the school is how this learning process is relevant for a curriculum. Can serious games work within the structure of school and relate to the competence aims that exist in the Norwegian school system? By closely observing the use of games in two schools, this study seeks to answer three interlinked research questions:

1. Do the games contribute to student engagement and activity?
2. How does the use of games match the structure and terms of school and guide the activities?
3. Do we find the competence the pupils have gained from gaming experiences in leisure time to be productive for school-based learning?

The remainder of the chapter will review the research literature on serious games and the results of using this approach to learning. Next, the two cases will be described together with the methods used and descriptions of the games. Finally, data from the two cases will be presented with accounts of activities and transcriptions from video material and a first level analysis. The chapter will end with a discussion and conclusions.

GAMES FOR LEARNING

The research on games for learning conducted over the last decade is extensive but suffers from incoherence (for reviews, see Clark et al., 2015; Young et al., 2012; Wouters et al., 2013; Connolly et al., 2012). One major reason for this lack of precision is that there is no general agreement in the literature on what constitutes a serious game (Young et al., 2012). A number of partly overlapping terms are used for the same phenomena, such as serious games, game-based learning, epistemic games and simulation games (Sitzman, 2011; Wouters et al., 2013). Some review studies include simulations (Vogel et al., 2006), while others include games made for entertainment (Connolly et al., 2012). Results of the review studies are conflicting, ranging from positive results in general (Clark et al., 2015), to describing the impact of games on student achievement as 'slim' (Young et al., 2012).

One challenge of assessing the quality of any learning appliance is that several factors other than the technology are important for productive learning processes. The reviews are inconclusive on how different settings, pedagogical structures and game design contribute to positive outcomes. The results of linking the use of serious games with group work, competition elements or even additional instruction are unclear (Clark et al., 2015; Sitzman, 2011; Wouters et al., 2013). One element that can be traced through two reviews, however, is that narrative games—including games that use cartoon-like or realistic visualisations—have a tendency to be less productive for learning purposes than games that are oriented towards schematic visualisations with no explicit narrative (Clark et al., 2015; Wouters et al., 2013).

One concern with using games in school is that games are generally played for leisure. Is a game that is compulsory to play, in fact, a game? Young et al. (2012) put forth this thought: 'a teacher…requires her class to play 40 hours of WoW [World of Warcraft] as homework, with students not doing so receiving a failing grade. Some students who may normally enjoy playing WoW might now find the exact same activity onerous' (p64). It seems clear that a game played purely because we decide for ourselves to do it, of boredom or interest or impulse, will be another experience

than to have a teacher select a game for you with the expectation that you learn from using it.

Given the wide variety of games and the lack of definitional clarity, the design, structure and goals of a game must be evaluated to assess how games can be productive in learning processes. Games can be slow or fast, skill-based or knowledge-based, competitive or collaborative, simple or complicated, and the classification of games is an area of research in itself (see e.g. Elverdam & Aarseth, 2007). Connolly et al. (2012) list 16 game genres. Wouters and Oostendorp (2013) look for what kind of instructional support a game provides and have categories such as reflection, modelling, collaboration and narrative elements. They find that structuring the gaming with instructional support is effective for learning outcomes. In particular, the study found that reflection prompts (in agreement with Vrugte et al., 2015) offering advice for modelling are effective, while the implementation of collaboration is not instrumental for learning. Regarding the design of the games, Clark et al. (2015) study sophistication of game mechanics, variety of player actions, intrinsic integration (Habgood & Ainsworth, 2011), and scaffolding. They do not find that these elements correlate significantly with learning effect, but games with a high level of sophistication and a large variety of game actions result in slightly higher scores on learning effect. Where the studies do find clear and significant effect on learning gains is with the inclusion of teacher support as scaffolding.

In spite of the variety of serious games researched, it seems clear that there are characteristics that distinguish games from other digital representations, simulations, animations and exercises. The pupils recognise games, and the interaction design leads to distinctive behaviours (Kluge & Dolonen, 2015). A minimal definition used in this chapter is that a digital game has a well-defined goal,[5] interactive possibilities with immediate feedback,[6] a set of rules to govern the activities, and some sequence of challenges to overcome.[7] The challenges can be based on competition between players, structural challenges in the game or a combination of the two. For a game to be serious, it will additionally have a subject matter that can be framed in terms of learning goals.

Important dimensions for learning include whether the game is time-based (Vrugte et al., 2015; Wouters & Oostendorp, 2013), the level of complexity (Clark et al. separates between sophistication of mechanics and variety of player actions), and whether it is collaborative or competitive (Wouters & Oostendorp, 2013). The issue of time is important, as games requiring tasks to be done as quickly as possible typically imply that skills of activity are more important than knowledge, and that time for reflection within the game will be limited. Regarding the level of complexity, games are typically oriented towards one clear goal, and then the structure and number of options and the complexity of each of them become relevant as these factors increase the possible situations the users/learners are confronted with. Collaboration and competition are important issues in technology-enhanced learning in general, and the use of games is no exception.

Games for Learning Math

There are a number of recent studies specifically investigating how math games can contribute to learning. Bakker et al. (2015) study the use of mini-games to support the learning of multiplication in grades 2 and 3; in particular, they focus on what combination of home and school play is most effective. The authors find *skills* and *insight* to be stimulated by gaming, but they find no significant effect on what they define as *knowledge* of multiplication. Playing games at home combined with school debriefing is the best strategy, echoing the positive results of planned reflection time in the work of Wouters and Oostendorp (2013) and Vrugte et al. (2015). Mahmoudi et al. (2014) used mini-games in a school context alone, and were not able to report a significant increase in knowledge gain. Hung et al. (2014) set out to study the use of math games in primary school, and the reduction of math anxiety, in particular. The authors find better learning achievement, increased self – efficiency and motivation with games, but no reduction in math anxiety. Ke (2008) experiments with drill and practice games among 4th and 5th graders in primary school. The author finds no significant 'cognitive achievements', but reports a better attitude towards math learning based on using games. Kebritchi et al. (2010) report better results using a game, but no increase in motivation.

Similar to the general reviews of games for learning above, there is a general lack of description of the games used, and it is therefore challenging to assess many of the different and partly contradictory findings. In general, the various experimental studies previously discussed mostly report positive learning results from gaming, but the results are more divergent when it comes to motivation issues. This may be surprising, because increased engagement is a major reason for introducing games in school. One explanation proposed by Wouters et al. (2013) is that when pupils do not choose for themselves to play the game, their engagement is affected. Another explanation suggested by Young et al. (2012) is that the structure of play in the classroom is often tightly regulated. Another reason Wouters et al. discuss is that serious games are different from entertainment games in that they focus on learning rather than entertainment.

When games are used for learning in school, the issue of transfer is crucial. It is clear that we increase the specific skills of playing a new game as we do it, but how the improvement materialises as a transfer to the curriculum is an open question. Several of the studies above implicitly study transfer using post-tests; however, studies that explicitly study transfer find less of it. For instance, in the studies of Vrugte et al. (2015) and Wouters et al. (2008) transfer is not found, indicating that what is learned in the game 'stays in the game' as a context- and game-dependent skill, rather that knowledge that is relevant for school curricula. This is also the conclusion of Long and Aleven (2014).

Looking at the design principles of math games in particular, Habgood and Ainsworth (2011) put forward the idea of intrinsic integration as a design characteristic, which was also studied by Clark et al. (2015). They both contrast

this to the commonplace idea of games for learning being designed for extrinsic motivation, (i.e. games that are "sugar coated" with entertaining elements are not directly related to the content that is to be learned). Intrinsic integration, meanwhile, links the core mechanic of the game to the learning content. For example, if the goal is to learn factoring, the core mechanics of the game and the action the user engages in must include the operation of matching the right factor to an existing number, such as in the game referred to in Habgood and Ainsworth (2011).

The results from research on serious games for learning mathematics vary considerably. There are reports showing significant knowledge gains (Hung et al., 2014; Kebritch et al., 2010) as well as studies that are inconclusive (Young et al., 2012; Mahmoudi et al., 2015). As is the case with games for learning in general, using games in school for learning mathematics that are relevant to the curriculum is challenging (Ke, 2008; Pope & Mangram, 2013). Transfer of learning outside of the game is a recurring concern (Vrugte et al., 2015; Wouters et al., 2008). The need for pedagogical structure framing the game—as meta-cognitive reflection—is underlined, both in general and in games for mathematics learning (Young et al., 2012; Ke, 2008; Vrugte et al., 2015). More specific issues include the ways in which high frequency interactivity can hamper learning (Kluge & Bakken, 2010; Ke, 2008) and how gaming can stimulate collaboration (Young et al., 2012).

PLAYING GAMES IN SCHOOL

Two different schools and grade levels are presented in this chapter. The data was collected in 2013 (grade 8, lower secondary) and 2014 (grade 5, primary); both schools are located just outside of Oslo. The students at both schools did a considerable share of their work in pairs, and the data from both grades is from the collaboration of these dyads. The secondary school had an experimental set-up with two large classes using different technology in the learning processes: one group of 37 students using a game (DragonBox), and the other group of 36 students using a digital environment based on step-by-step feedback for solving algebra exercises. The primary school had a station-based learning structure, in which the pupils were assigned different activities. One of the activities was to play an algebra game. In the upper secondary school, the algebra project consisted of 8 hours distributed over three weeks; game play filled about half of this time. In the primary school trial, the project period was also three weeks. The pupils spent about 10 1/2 hours total on the project, and spent 1–2 hours of this time playing the game 'Bike Racing Math Algebra'.

The Games

In this chapter, we see design are important for the activities the students engage in; consequently, they are also important for the learning processes. Symbol manipulation is a fundamental part of algebra. When the pupils directly manipulate

a game using touch screens, moving symbols on the screen is an appropriate choice for game mechanics. This is also the choice for the first algebra game.

DragonBox was used on tablet computers for this study. The game consists of a number of boards to be solved, gradually increasing in difficulty. The user is required to manipulate elements analogue to an equation, according to specific rules. The game consists of two boards corresponding to the two sides of an equation, and a repository of objects positioned at the bottom of the screen (see figure 1). The purpose of the game is to (1) solve the equation in each level; (2) in the prescribed number of steps; (3) without any unnecessary objects present on the board. Solving the equation is the condition for completing a board. The player may repeat an exercise but cannot skip levels. The reward for completion of each board is 1–3 stars, depending on how many of the three elements above were solved. Along with increased difficulty, interactive possibilities are gradually introduced and expanded (see expanded description in Appendix 1).

Figure 1. DragonBox in a position where the game expects the user to move the fly from the repository below and into the dents that have opened as "denominators"

Bike Racing Math Algebra is a considerably simpler game. It consists of a race between four motor bikes where the player speeds up his bike by providing the right answers to algebra problems shown on the screen. The answers are provided

by responding to multiple-choice questions with four alternative answers. Correct answers speed up the bike, while wrong answers slow it down. If the player does not answer, the speed of the bike slowly decreases.

There are three levels from which the player may select: easy, medium and hard; nobody in the test played the medium level. The easy level has exercises of the form y – a = b. The hard level includes exercises of the form ax + b = c. Each race concludes with the option to provide the player's name and be registered with the number of points achieved; if the score is high enough, the player enters the high score list.

Bike Racing Math Algebra is clearly a serious game. The goal is to provide the right answers to speed up the bike and win the race. The players are given a sequence of questions to answer; solving algebraic equations is the learning goal. The game is time-based, as it rewards fast answers; competitive, offering high score lists and virtual opponents; and simple, in that the sophistication of mechanics and variety of player actions are not complex.

Figure 2. Bike racing math algebra. This is the initial part of the race, where the three competitors pass "your" bike and leave you at position as last in the race

METHOD

This is a naturalistic study performed during regular school activity. The data is based on observation and video. Four pairs of students in the 8th grade and three pairs in the 5th grade were selected for observation. This selection was based on the teachers' assessment of these students as talkative and informally representing varied levels of achievement in mathematics. General observations of the pupils' activities with technology related to the research questions are described. More specifically, excerpts are selected of situations where the pupils talk about their operations while doing them or characterise use and operations more detached from the actual operation. In addition, recurring patterns of use are reported from the material (Derry et al., 2010). This enables analysis of the pupils' assessment of what they are doing, in action and in reflection (Norman, 1993; Schön, 1992), as well as the pupils' use over time.

Experimenting with a Game – Using DragonBox

In addition to the qualitative observation study reported here, a quantitative pre-/post-test was conducted in the 8th grade, comparing the pupils who used Kikora, an interactive tutoring system based on standard algebra equations and step-by-step feedback to the users of DragonBox. The pupils using the tutoring system did significantly better, improving their results 92% between the pre- and post-tests, whereas the pupils using the game improved 49% during the course of the project (Dolonen & Kluge, 2014). It is important to note that about half of the activity in the project was the same for the two groups, consisting of plenary discussions and presentations from the teacher, which also accounts for progress documented in the pot-tests.

An additional element in this project is that the pupils using DragonBox spent considerably more time using the application. Time studies show that the pupils using Kikora spent >20% less time—57 minutes—using the application, compared to the pupils using DragonBox. This difference was due to several factors, including greater time requirements for technical administration such as charging, and the fact that Kikora ran on PCs and was internet-dependent, while DragonBox ran on tablets and could be used as a standalone. In addition, the pupils enjoyed using DragonBox and therefore occasionally went over time playing the game. This gave pupils more time on task, which should have provided more opportunities for learning and a better result; however, the pre- and post-tests show the opposite. Below, an interaction analysis will be used to explore these results further.

Observing the pairs using the game, the engagement is obvious in all groups. The pupils stay focused and on task throughout the sessions. There are several examples where they play more than the amount required of them, and several groups using the game explicitly expressed regret when the project was over.

In the excerpt below, the pupils have played for some time and have reached a level where fractions are included. They try to find ways to operate the fractions and interpret the signals from the game:

1. Jane is pushing a dice with one dot (representing the number 1) into a figure, which eliminates the 1-dice.
2. Jane: 'There!'
3. Then Jane tries to do the same operation on two 1-dice on the other side. The 1-dice is the numerator, with a figure in a denominator position. Then she reverses the direction and tries to put the figure into the dice. Then she tries to put the other dice with one dot inside the dice on the fraction line with one dot. This is done repeatedly, and Brit also tries.
4. Jane: 'Shall we just try it?'
5. Brit: 'OK'.
6. Jane moves one object over another with an inverse value to eliminate it.
7. The box is signalling that they have solved the task.
8. Jane: 'No, it will be 'Yuck'—I know'.
9. Then the machine response is 'Nam', which implies that they have done it correctly.
10. Jane: 'No?!' (very surprised)
    …
11. Jane: 'When it is many similar, it is "Yuck"'
    (0:08-0:54 c11_M_RSB_8B_V_2013_10_21_JD_02.MOV)

This episode shows how Jane and Brit operate the elements. They have previously put the 1-dice into a figure (numbers 1 and 2 above). This parallels multiplying a number with 1, which in effect eliminates the 1. Following the successful placement of the 1-dice into an object, they also try to put the 1-dice (as a nominator) into the denominator of fraction; this is a not a meaningful move in algebra, particularly as we do not know the value of the denominator. The other move, trying to merge 1 and 1/n, could be meaningful (resulting in n+1/n), but judging from the context, they do it to eliminate the 1, which cannot be a consequence of this move (number 3 above). In 4–6 above, they are more reluctant; Jane asks Brit before she acts but then decides to try it, and is able to eliminate an object (representing the operation a + (–a)). As a result, the unknown is isolated on one side. As this is the condition for termination, Jane anticipates that there will be a 'Yuck', (8). A 'Yuck' response from DragonBox signifies that the side opposite the unknown could be further reduced, (e.g. the reducible equation $x = 7 + a – a$ that can be reduced to $x = 7$). Jane is

surprised when she sees that the result is good (10). This implies that she was still convinced that the objects could be merged, even though she did not manage to do it. Later, she confirms a correct understanding of the conditions for 'Yuck' (11), but there were indications of Jane making new interpretations of the operations above and turning towards a more correct understanding of the operations on fractions.

The pattern in the episode above was repeated among other pupils. They tried to merge objects that could not be merged in any meaningful way in algebra. In another group, one of the participants repeatedly tried the same operation, merging 1 into the denominator in a 1/n fraction, insisting that 'This should work!'.[8] This recurrent pattern seems to be based on earlier operations of merging, similar to the operation Jane and Brit did in the excerpt above (4–6). In the game, n/n can be merged and the result is 1. The pattern is repeated as the pupils consider the objects on the canvas that may be merged, for example, seeing 1/n + n to be sufficiently 'similar' to be merged; however, this operation is not valid in algebra.

Other episodes show that the pupils are looking for ways to make sense of the environment. One pair of boys (the second group observed), is less action-oriented and more analytical than the others. In a session similar to the one involving Jane and Brit, the boys try to put objects together and mix up fractions, addition and multiplication. One of the boys says, 'I am not sure whether we are to take the same [object] or different'. He refers to the operation of merging two objects—an additive operation in which the objects must be the inverse of each other—or shortening a fraction, for which the objects have to be identical. What he seems to refer to is the fact that sometimes it works with identical objects (in fractions n/n), and sometimes it works with inverse objects (in additions n + (–n)). Yet, it is the object (the figure) that captures his attention, and not the operation. Later in the same session, he searches the game for rules: 'It have to be a set of rules here somewhere, I do not know what I should do, like'.[9]

In a third group, (consisting of one girl and one boy), the pupils try to analyse negative entities, which are illustrated by inverse colours. The boy says, 'The black ones [i.e. negative entities, as –n] cannot be taken away'.[10] This is not a valid conclusion, and may reflect the fact that they initially have lighter colours on the board, which they eliminated by changing identical objects in the storage and then moving them onto the board to eliminate the positive entities, not the other way around.

In a fourth group the pupils have come to a level in the game where they can multiply numbers by putting them together and getting the resulting product. A simple operation of multiplying 6 by 6 is confusing for them, and one of the boys bursts out, 'What *happens* when we take the two 6 [dice] and get 36?!'. Later the same boy says, 'We have to put things together. Try something. There. What did I do? I don't know'.[11] They later experiment with fractions and find the right solution—that n/n can be merged and will result in 1—but fail to see the logic behind it. They conclude, 'They have to be equal, for some strange reason'.[12]

In the second group, both pupils burst into laughter when they put a 3-dice and a 2-dice together and get 6. They obviously think they have done an additive operation, and were expecting the result to be 5.[13]

The activities and utterances above illustrate several elements of game use. First, the pupils are active, although the patterns vary. Some act in a trial and error pattern, while other pairs have a more reflective approach, trying to analyse things before they perform operations on the screen. Yet, all groups are active and focused. Second, they explicitly and implicitly look for and develop rules. They seek patterns in which to operate and rules to follow in order to do the right operations. One pupil even searches DragonBox for the rules and becomes frustrated when he does not find anything. Third, the pupils fail to see the logic behind the operations. They continue to try invalid operations throughout the period, but gradually do this less often. This behaviour appears to rely on some kind of pattern recognition and they find the logic to be unpredictable. They characterise it as 'strange', and do not see the relation to mathematics, even in operations they obviously know in 8th grade, such as adding or multiplying single-digit numbers.

In the next section, we turn to the game of algebra played by 5th graders to learn how to solve equations. It will be important here to study whether the results above will resonate with the empirical data gathered in 5th grade.

Learn by Action Game Play – Bike Racing Math Algebra

In the first experimental set-up, the pupils are younger and the algebra simpler. The video cameras followed three pairs of students. That study included a pre- and post-test, but no experimental comparison; therefore, it only measured progress for the whole period, which was shown to be considerable (Naalsund et al., 2015). The project consisted of a mix of individual work, whole-class teaching with dialogue, and group work. The data for this chapter is taken from the work of the three groups, and only from the session in which they used the game *Bike Racing Math Algebra* from Math Nook.

Compared with the level of engagement in the 8th grade, the pupils in grade 5 were playing the motorbike race with even higher intensity. The game is time-based, and hesitation was punished with reduced bike speed. The game is designed in such a way that the player always lags behind in the initial phase of the game and has to pick up the three bikes in front to win. This setup was clearly able to engage the pupils, and they played with passion and focus.

The pairs took turns, alternating play every second game. The person not playing was giving advice in some pairs; in other pairs, they were competing between themselves to achieve the highest points, while the pupil not playing just watched.

The pupils in the first group, consisting of one boy and one girl, are collaborating. Initially, they are guessing, but in the next run they decide to try to perform the calculation. They share the tasks so that the boy does the calculation when the equation is in the form $y + a = b$, and the girl take the equations in the form $y – a = b$.

The boy seems to be calculating the numbers, although he makes several mistakes. The girl is counting from either a or b and the necessary numbers upwards to reach a + b, which will be the answer to the equation in the form y – a = b.

The second pair selected for observation consists of two boys. They choose a completely different strategy, illustrated by the excerpt below:

12. John: '…it [the answer] is not 2 and it is not more than 9'.
13. Jim: 'Not more than 9'?
14. John: 'It is almost never more than 9 and [inaudible] …never less than 2…or 4'.
15. Jim: 'It is often 8, 5 or…'

As they have this conversation, John is clicking very fast, seemingly at random; however, a closer look reveals that he seems to be following his own rules. When the pupils continue, John repeats 'not above 10' as he clicks very quickly on different alternatives, generating a considerable number of wrong answers. Still, the pair perform well in the game, due to fast fingers and the reward implemented for high frequency clicking. There is no sign of the group adjusting their strategy throughout the different play sessions, despite the high number of wrong answers.

In the third group, two boys take the same approach of random selection with the rules developed in the previous group. The boy who operates the game is confronted by his partner:

16. Hans: 'Guessing, is that what you do also (referring to their neighbours, the group referred to above)'?
17. Ole: 'I am calculating a bit—straight up in the head'.
18. Hans: 'he'?
19. Ole: 'I am calculating a bit—straight up in the head'." (repeated 4–5 times as he answers)

Over his next 52 answers, (the rest of the game initiated above), he takes an average of 1.79 clicks to find the right answer. Using a probability test, this is significantly better than arbitrary clicks (with a 0.99 significance test). The average result with arbitrary clicks would be 2.5 clicks to get the right answer. His results in the next game are slightly weaker—2.15 average from 127 answers—but still significantly better than random (also on the level of a 0.99 significance test). This indicates that the 'straight up in the head' calculation has some effect, combined with the rules they have borrowed from their neighbouring group to eliminate certain options as illustrated above.

In all three pairs, we see that the pupils develop strategies for playing the game. They all improve their results throughout the game session observed, in terms of points gained and relative results in the race (even if the particular case where answers are counted is an exception). The first group specialise in the two different types of equations they get, one pupil focusing on equations involving a minus sign, the other pupil focusing on the plus sign. In the other two groups, there are no clear patterns of cooperation; instead, they prioritise clicking pace and look for ways to

minimise wrong answers. It is also interesting to note that none of the groups change their strategy during the course of game play. The improved results, as measured by the game, are attributable to improved performance within their chosen strategy.

DISCUSSION

The traditional method of solving algebra exercises on the board and later having the pupils solve similar problems, may need alternatives. The question is whether the games studied here can be an answer this challenge. The results of the pupils playing DragonBox show that the conventional method of solving equations outperforms the game, as measured by a pre- and post-test, despite the fact that the 'gamers' spend considerably more time on task. Below, we try to isolate the reason for this result, while also discussing use of the two games together for commonalities and differences.

The methods in this study allow for close observation of the activities and dialogues the pupils engage in while playing the games. The data shows how the pupils try to make sense of operating the games on a detailed level. During the gaming sessions in the two trials reported in this study, the pupils were intensely active, and non-relevant activity was not observed, which is remarkable in a math lesson. The 8th grade time studies show that pupils played more than they were required to; similarly, the teacher in grade 5 had to work hard to get the pupils to turn from gaming to other activities. Class observations show that this is true for all the pupils in the class. Operating in pairs, the pupils closely follow what is happening when they are not operating the game, and some also give advice. This type of engagement is a major achievement in a math class, on a level the mathematical teachers involved said they seldom or never experience in class. The question now becomes: what is the proportion of math in the activity, and how do the activity and engagement contribute to school-relevant math?

Bike Racing Math Algebra is a time-based game. Initially, three bikes pass 'your' bike as the game starts (see figure 2). This suggests that you are in a hurry, which the pupils immediately understand. Between games, the pupils engage in reflection, in which they plan how to go about handling the equations. Only one of the three groups observed focuses on getting the right answer before clicking on an option; the other two groups find strategies to maximise points and win the race. These two groups choose a trial and error strategy that proves to be successful in winning the bike race in the game. As a learning strategy, non-reflective trial and error is not considered productive (Vos et al., 2011; Norman, 1993). Rather, they move away from the logic of the exercises, which is to understand equations, to perform operations to isolate the unknown and to calculate. The two pairs instead find a mode of operations to win the race and maximise points at the finish line.

DragonBox is not inherently time-based, (i.e. time measures are not integrated into the game), but time and speed still matter as the pupils compare how far into the game they have gone, representing how many boards and levels they have completed.

Even though they act at a considerably slower pace with DragonBox than with the bike race, trial and error activity emerges here too, in a slightly different form. Based on what seems to be a kind of pattern recognition, the pupils try to match the same objects, possibly inverted, or to eliminate 1 as a factor or divisor. The problem is that they do not differ between how they can operate on n+n, n–n, 1*n, n/n, 1/n, and n/1, each of which requires a very different operation. This goes for all the observed pairs; they are all surprised that it is not possible to eliminate 1 in 1/n, when it is possible in n/1. In very simple operations, they are also not able to differentiate between adding and multiplying, or between positive and negative numbers. This makes the weaker results in the post-test plausible, as compared to the group using the standard method of solving equations. In this game world where they cannot discriminate between the elements, the pupils revert to operating the game by trial and error. They also repeat faulty operations. The observations indicate two reasons for this seemingly futile activity. First, the pupils quickly repeat operations in a way that indicates that they believe that an operation was done wrong the first (several) times. Second, and more interestingly, this repetitive activity indicates that the pupils do not reflect on what may be wrong with the operations they try, and do not appear to consider alternative operations.

Still, the pupils improve in their results and operations of the game. In Bike Racing Math Algebra, the improvement is mainly linked to how the pupils increase their speed of operation, optimised for winning the game. They also relate to the points they get, as it is visible on a top score list, and two groups select the most advanced equations because it gives more points. Yet, this choice does not seem to be a part of their reflections when in the game, as it is not clear to them how points are awarded in the game. Although the group that does analytical reflection, (i.e. deciding what operations to do, and then doing them), increases their speed and therefore improves their results, the girl continues to count rather than calculate, and the boy continues to perform calculations with no improvement. The boy who calculates ‘straight in the head’, as he calls it, does not improve in this type of estimated calculation, but rather increases the number of wrong answers, which may be due to fatigue from the speedy operations. Yet, the speed increases, as well as the pace of deciding which operations to do, as a type of pattern recognition of the equations. This illustrates the problems that arise when the goal of the game and the learning goal differ (Habgood & Ainsworth, 2011). The pupils are able to improve the game results without improving their algebra.

The pupils using DragonBox also improve. Even though they continue to repeat faulty operations, all of the observed groups gradually improve in finding more of the right combinations. As the game gradually becomes more similar to standard algebra, replacing figures with dice representing numbers, the pupils still have problems seeing how it relates to calculation. Previous studies have also shown that the pupils treat the numbers similar to figurative symbols, failing to see that different symbols can merge to a result (e.g. that 2 multiplied with 3 is 6), because they continue to see them as symbols of different categories, persisting with the logic

presented in the earlier stages of the game. The dice metaphor may signal adding more than multiplication, when we look at how dice games are structured.

One type of behaviour that comes with the figurative world is that the pupils act intuitively on similarities. The operators between the elements are downplayed in DragonBox, and the figures become the centre of attention. This triggers the trial and error activity that can be seen to emerge from previous leisure game activities. We do not have data on the leisure-time gaming of the observed pupils, but we can expect them to have considerable gaming experience. The high frequency interaction hampers reflection (Kluge & Bakken, 2010; Vos et al., 2011) and can be seen to hinder the development of algebraic understanding.

A common trait seen when the pupils use the games is how they look for systematic behaviour from the environment. They search for the rules governing the world in which they are engaged. One pupil is explicit in wanting to have the rules formulated in DragonBox, but the other pupils explore the game for the systematics that govern the behaviour. They do tentative operations—'try something', as one pupil says—and through the operations, they try to reveal the logic of this particular world. They also engage in a kind of inductive reasoning: if one operation works, they look for other, slightly different situations in which it might also work. For instance, in DragonBox, they find that the number 1 (when acting as a factor) can be merged into a symbol, and the try to do the same when 1 acts as the nominator in a fraction. The problem is that, when they try to do this and it does not work, they struggle to find a way to proceed and are not able to do so. The pupils do not reconsider their tactics in any way that was observable in the data, for instance, changing the way fractions or eliminations are handled. We can observe some change in behaviour, but the faulty activities also remain, indicating that they have not grasped the logic behind the response of the game. Rather, the opposite happens; they underscore verbally that they do not understand the rules governing this game world, and express that they do not understand how it relates to mathematics.

In the bike racing game, the investigation of rules takes a more dysfunctional direction. Two groups find that speed is more rewarding than providing the right answers, and they try to optimise within this framework. They eliminate certain options in the multiple-choice questions, and consequently increase the possibility of guessing correctly with fewer wrong clicks. They look for systematic behaviour in light of what is rewarding in the game. This is termed 'the wandering mouse problem' (Young et al., 2012), and is associated with the task being too hard for the user (Ke, 2008).

In Bike Racing Math Algebra, the gaming behaviour of high frequency clicking is productive toward the goal of being the first bike to cross the finish-line, but does not build corresponding knowledge in algebra. The time-based game reward stimulates high-speed interaction, and the pupils immediately resort to a gaming activity that makes reflection difficult. An element that can be seen in both games is what has been called 'entertainment value' (Sitzman, 2011); this element is not found to correlate with better learning outcomes. The results of this study agree with

this finding; the pupils enjoy the entertainment of action in such a way that substance learning is downplayed.

The narrative character in Bike Racing Math Algebra, which can also be seen in DragonBox as capturing figures, has a dubious relation to learning outcomes. Both Wouters et al. (2013) and Clark et al. (2015) find that games with narratives might be less effective than games without a narrative. One reason for this is what Sitzman (2011) calls entertainment value: the narrative may consume too much space for curriculum-relevant learning to happen.

Although some of the gaming results are disappointing, the inquiry into systematic behaviour is interesting. This aligns with elements in the idea of intrinsic integration (Habgood & Ainsworth, 2011). If mastering the logic of the game achieves the learning goal, the pupils will search for the rules and systematics that governs the game, and will in fact explore the digital environment for mathematical structures, and more generally, for relations, which is an important element in many learning processes.

CONCLUSIONS

Three questions were posed in this chapter to investigate the use of algebra games in school. The first related to engagement and activity. During mathematics lessons in compulsory school, it is a challenge to engage a whole class of pupils. Compared with more traditional teaching and learning, the engagement and activity is remarkable. The time on task is 100%, sometimes even higher, as the pupils extend game play beyond school hours, maintaining engagement and focus over a long period of time.

The second question is less positive, studying use of the games related to school learning goals. Even though the teacher may see a level of engagement they have never experienced, it seems to contribute very little to learning relevant to the school curriculum. In the case of the Bike Racing Math Algebra, the pupils found ways to work the game that were compatible with winning the race, but these techniques cannot be seen as productive for algebra learning. In the case where the pupils used DragonBox, the lack of learning effect was documented in a pre- and post test. The game had a kind of stealth learning approach (Ke, 2008), hiding the standard elements and operations in a figurative language. The pupils did progress to learn the operations of the game, but improved significantly less than the group using a more traditional method for solving equations. The pupils using DragonBox did not translate the operations and relations they recognised and performed in the game to the traditional algebra exercises presented to them in the test.

The last question considers how the competencies this gaming generation have acquired may be used for productive school-based learning. One piece of this answer is the activity the pupils engage in when playing. They enter into a game-mode that easily turns into a trial and error type of operation that is counterproductive to deeper learning. The initial activity triggers more activity, leaving no room or time for reflection. The other part of the answer to this question is how the pupils seem

to make a practice of searching an environment for structure, rules and relations. They are used to entering a game world and investigating the laws that govern this world. If properly used, this inquiry approach can lead to the search for physical laws in a science simulation, for instance, or algebra rules in a math game. For a game to engage pupils and lead to productive learning processes, it requires a design that allows the pupils to investigate its mechanics, similar to learning processes in a simulation. To some extent, this will be contrary to games in which the rules exist as tools a player utilizes to win, rather than being something to discover.

In conclusion, the pupils were engaged and focused using the game, but the curricula-related learning outcome was slim. The pupils quickly went into an unreflective trial and error mode that was not productive for learning. On the other hand, the explicit and implicit inquiry mode the pupils related to game play may be used in a productive way if games are designed according to such a principle.

NOTES

[1] http://www.medietilsynet.no/globalassets/publikasjoner/2015/faktaark_barnogdataspill_2014.pdf (in Norwegian).
[2] http://www.nrk.no/kultur/norske-skoler-dropper-handskrift-1.12486443 (in Norwegian).
[3] See http://timssandpirls.bc.edu/timss2011/downloads/T11_IR_M_AppendixE.pdf
[4] http://www.uv.uio.no/iped/forskning/prosjekter/ark-app/publikasjoner/
[5] One goal is most common, but games with several goals also exist.
[6] One can also imagine a game where you have to do a set of combined and dependent activities before the game gives feedback, but the general idea of feedback of interaction will be similar.
[7] This constraint will exclude systems purely made of simple initiate/response operations without any additional framing (e.g. quiz).
[8] c11_M_RSB_8B_V_2013_10_21_KS_01.MOV.
[9] c11_M_RSB_8B_V_2013_10_30_AK_01.MOV.
[10] c11_M_RSB_8B_V_2013_10_24_JD2_01.MOV.
[11] c11_M_RSB_8B_V_2013_10_23_JD_03.MOV.
[12] c11_M_RSB_8B_V_2013_10_28_JD2_01.MOV.
[13] c11_M_RSB_8B_V_2013_10_23_AK_01.MOV.

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APPENDIX 1

Description of DragonBox

The game consists of square-like objects, which need to be moved around in the interface, dragged from the repository and dropped on to the boards. Initially, the squares are figurative (fantasy figures and "angry birds"-like animals), then squares with dice-like dots representing numbers, and finally letters and numbers are used according to standard algebra notation. The game consists of a reasonably small number of operations based on movement and tapping on the square objects:

- Drag an object from the repository and onto the board
- Eliminate empty objects (swirls in the early chapters and zeroes later) on the board by tapping them with the fingers
- Invert an object in the repository by tapping it with a finger (invert the colours on a figure or change the sign on a number or letter)
- Merge objects, initially represented as figures or dice sides with inverted colours, in later chapters represented as numbers (that can be added) and letters
- Eliminate identical objects on a fraction line so the result becomes 1
- Drag a factor of 1 into an object to eliminate it, or out of it – as multiplying with one equals the object

In later stages of the games it is also possible to drag objects between the two halves of the board, leading the sign to be inverted (or the colour). Objects moved from the repository can be placed as free objects on one of the halves in the early chapters of the game. In the later chapters, the objects are linked with operators, added to the equation on the sides and placed as a factor when placed close to other objects or as a divisor adding a fraction line if placed below another object.

The goal of the game is to isolate the 'x' (in the earlier levels represented as a box) on either the left or the right board. This is done by eliminating the objects on the board containing the x, and simplifying the other board as much as possible. The objects in the repository are suited for this task, and they are tailored to each board. When the user drags an object onto one of the boards, the algebraic rules, are activated, such as doing the same operations on each side of the board (i.e. equation), rules for factoring, for fractions and more. e.g. if the user drags an object to be added or subtracted onto one of the boards, a dent shows on the other half, and the only operation allowed at that point in time is to add/subtract the same object to the other half. Similarly, if an object is multiplied to an object (as a factor) or divided (as a divisor), a dent opens in all the other terms (objects), and the only option available to proceed with the game is to fill the dents.

This game clearly fulfils the requirements of a serious game as defined in page xx, containing well-defined goals, rules, immediate feedback, and a sequence of challenges. The learning goals clearly relates to algebra, evident as the objects gradually turn into more standard algebra notation. Regarding the dimensions

outlined in the review, DragonBox is not inherently time-based, as players are not rewarded according to speed of answers. The game is complex, with a number of actions possible and qualifying for a sophisticated mechanics, still have a closed structure in the way one game have to be completed before it is possible to move to the next. The game also have specific dependencies as a player have done one action, it has to be followed by a specific action according to algebra rules.

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ANDREAS LUND

7. I AM CONNECTED, THEREFORE I AM

Polycontextual Bridging in Education

We will burn that bridge when we come to it.
Johann Wolfgang von Goethe (1749–1832)

INTRODUCTION: SCHOOL AS ONE OF MULTIPLE CONTEXTS FOR LEARNING

A few generations ago, information used to be a scarcity. In order to get access to updated information, people met outside of churches after services or frequented the local pub or other sites where people naturally congregated. In order to transcend these geographical and physical parameters, print media and school became the primary institutional responses to increasing and improving the shared flow of information. With the digitization of information, this once-precious commodity has become abundant and easily accessible, even to the extent that the main challenge is not to merely to locate information but to check its origin and validity, question it, and make syntheses from diverse and sometimes conflicting sources. However, turning an abundance of information into relevant and productive knowledge that is applied when facing complex problems and challenges amounts to a sophisticated competence involving accessing available cultural resources, connecting with people with expertise in various domains or practices, and using object-oriented strategies.

One consequence is that, in what has become known as the networked knowledge society (Castells, 1996; Gee, 2000), we can identify a plethora of knowledge forms, knowledge logics, and epistemologies (e.g., in gaming, large group collaboration, use of models and simulations, participation in new communicative ecologies, etc.). This amounts to a situation where networked and digital technologies impact on the way we engage with knowledge, such as exercising epistemic agency, as well as understanding how knowledge is represented in diverse ways depending on the discipline or domain in question (for extended discussions, see, for example, Lund, Furberg, Bakken, & Engelien, 2014; Lund & Hauge, 2011). In this situation, schools no longer exercise a monopoly or hegemony connected with knowledge work located in authorized learning resources such as textbooks. As digital and networked technologies suspend constraints in time and space, school becomes one of several arenas for knowledge work and knowledge construction; its hegemony as the locus of what counts as valid knowledge becomes contested. There is even a danger that

E. Elstad (Ed.), Educational Technology and Polycontextual Bridging, 129–145.
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schools might become disconnected from learning activities that increasingly draw on digital artifacts, as well as the life worlds of heterogeneous classroom populations (see, for example, Kumpulainen & Mikkola, this volume). On the other hand, there is no gain in unreservedly and uncritically copying such activities in schooling (see, for example, Kluge, this volume). The heated and often primitive debate as to whether digital technologies merely boost or impair learning testifies to the skepticism toward opening schools up to practices developed and cultivated out of school—hence the invocation of Goethe in the caption of the present chapter.

One of the first influential scholars to examine learning in and out of school was Lauren B. Resnick, who, in her famous 1987 presidential address (Resnick, 1987), explored four broad contrasts between these sites, categorized as:

- individual cognition in school vs. shared cognition outside,
- pure mentation in school vs. tool manipulation outside,
- symbol manipulation in school vs. contextualized reasoning outside school, and
- generalized learning in school vs. situation-specific competencies outside.

Although these observations were made 30 years ago (at the time of writing) and have since been further elaborated on, as Kumpulainen and Mikkola do in chapter four, they still point to fundamental challenges for schooling in the knowledge society: how can schools recognize, open up to, and appropriate out-of-school practices that are constitutive of learning and development? Among the many projects that, following Resnick's analysis, further explored and documented the educational potential found outside of school was the Fifth Dimension Project (Cole, 2006). I highlight this particular case since it focused on young learners' cultural and socio-economic diversity and affective and social dimensions, and integrated digital technologies (e.g., in the form of gaming) in after-school activities. The Fifth Dimension Project was successful and has served as a model for how we can enrich schooling by making systematic and theory-informed connections to contexts beyond the classroom.

However, such connections do not correspond to merely transferring or importing out-of-school practices into schooling. Neither do they merely apply to bridging or connecting physical or geographical locations and the practices that are found there; they also involve connecting to available cultural resources—social, material, linguistic, and symbolic. In this section, material resources in the shape of digital technologies are of particular interest and will, consequently, be discussed in some detail. Finally, bridging carries temporal dimensions in the sense that it can also link past and current practices to possible future ones.

Thus, before we turn to the contributions in section two in the current volume, we need to further conceptualize what bridging entails in this particular section. As all the contributions share fundamental assumptions about learning that can be subsumed under a sociocultural perspective, this perspective will also serve as a theoretical and methodological lens in the present chapter. In particular, notions of transfer/transformation, boundary crossing, and expansive learning will be activated,

although rather briefly. The rationale is to approach the contributions in this section not merely as examples of bridging but as empirical carriers of principles that may be, if not generalizable in a traditional sense, de-contextualized and re-contextualized in different contexts and where other cultural resources may be available.

A Sociocultural Perspective on Bridging

When we connect worlds, ideas, perspectives, people, or sites, it is in order to move something from one position to another or to share something that has existed in a state of disconnection or discontinuity. Such connections are ideally made across time and space. However, such processes are complex and involve transition and transformation. As Beach (1999) and Packer (2001) show, the transfer metaphor is problematic in the sense that it is historically an individual notion, static, uni-directional, and context-insensitive; does not acknowledge the dialectic relationship between agent and context; and thus blurs the kind of agency that is involved.

In education, transfer has often referred to "the appearance of a person carrying the product of learning from one task, problem, situation or institution to another (Beach, 1999, p. 101), neglecting the situatedness of tasks, tools, and agents. Consequently, Packer (2001) makes a case for conceptualizing transfer as transformation; i.e., an ontological position where the person emerges in interplay with other humans and contextual resources. Beach has identified four types of such interplay, what he calls transition. *Lateral transition* occurs when an individual moves from one activity to another that is historically related (e.g., a linear movement from school to work). The material in the current section does not display any prototypical example, although both Kumpulainen and Mikkola (in case 2, see Table 1 in Chapter 2 this volume) and Rasmussen (Chapter 4) display connections between current and possible future practices. *Collateral transition* occurs when persons move in a multidirectional way between two activities, such as school and leisure activities. Kluge (Chapter 6) and Brevik's studies of gaming (Chapter 3) lend themselves to this category, while at the same time revealing instances of discontinuity. *Encompassing transition* occurs when it unfolds within an activity that is itself undergoing change, such as when teaching and learning take place in increasingly technology-rich environments. Furberg and Dolonen's study (Chapter 5) is a prime example. This type of transition also involves heterochronicity as agents and contextual factors (e.g., technologies) follow different developmental trajectories. Finally, *mediational transition* involves an activity that is not yet fully realized or experienced, "something that is not yet there" (Engeström & Sannino, 2010, p. 2). This opens up for an "as if" experience, or simulations, models, and scenarios that might transcend or expand the object of curriculum-oriented schooling. Again, all the contributions in this section lend themselves to this approach, although to varying degrees of future orientation and instances of discontinuity. Rasmussen's chapter (7) on microblogging is, however, a prime example, as it also documents how the practices and technologies involved have undergone development.

Beach's (1999) four categories of transitions have a common denominator in that they depart from transfer or the mere application of a skill or practice that has been obtained in a different context. Rather, they involve transformation of the person as well as the practice in question, a central tenet in sociocultural approaches to learning (see, e.g., Wertsch, 1998). This is a principle that can be de- and re-contextualized and lends itself to analytical generalization (Yin, 2010), as we will discuss when we approach the empirical contributions in this section.

Another implication of bridging framed in a sociocultural perspective is that agents move between contexts and activities; i.e., they cross boundaries as "brokers" (Wenger, 1998), often utilizing boundary objects that are malleable across activities but that also give structure and direction to activities that originate in different contexts and require horizontal expertise in order to become productive for learning (Akkerman & Bakker, 2011; Star & Griesemer, 1989). While boundary crossing and boundary work traditionally have been attributed to diverse physical settings or practices, it is important here to invoke Beach's fourth type of transition from current or traditional activities toward the expansion of such activities and, thus, produce something (approaches, use of artifacts, practices) that might take us beyond historically established classroom practices. Still, and as particularly the contributions by Kumpulainen and Mikkola (Chapter 2) and Brevik (Chapter 3) show, we need to address the interface of formal (school) and informal (learners' life worlds) settings and the hybrid practices that emerge before we turn to other forms of boundary crossing that we can identify across the chapters in the present section.

Building on Resnick's (1987) four contrasts (above), Kumpulainen and Mikkola (Chapter 2) expand on the contrasts between formal and informal learning in a detailed table, but without losing the view that these labels do not apply to discrete points on a scale but as activities that merge in so-called third spaces—zones where hybrid practices emerge. Such zones or spaces must not be romanticized; they may hold tensions and contradictions and force participants to part with privileged positions, convictions, ideologies, and even identities when they negotiate the boundaries between diverse activity systems. Also, it may prove difficult to maintain or construct a shared object. However, when boundary crossing is successful, boundary zones may yield new opportunities for learning. There are numerous studies showing how this happens, but often in connection with workplace learning and diverse expert communities (see, e.g., Akkerman & Bakker, 2011; Engeström, Engeström, & Kärkkäinen, 1995; Konkola, Tuomi-Gröhn, Lambert, & Ludvigsen, 2007).

In their review article on boundary crossing and boundary objects, Akkerman and Bakker (2011) identify four "learning mechanisms" that may materialize at boundaries. *Identification* may be challenged when different practices are not aligned and the participant experiences discontinuity between, e.g., her identity as a pupil and a leader in the local youth community. This tension may turn out to be detrimental, but can also be used to trigger agency in school. In this volume,

Brevik's study of "gaming outliers" (Chapter 3) points to the circumstance that these pupils find it difficult to bring their gaming identities as proficient English users into school (discontinuity) despite the fact that they prove to produce better results in their L2 (English) than their L1 (Norwegian). *Coordination* is closely linked to communicative connection and translation between practices or perspectives, often mediated by boundary objects. The authors refer to one example where grades function as boundary objects that mediate communication between schools and higher education. We see one such example in Furberg and Dolonen's study of digital representations in the natural sciences (Chapter 5), but, as in Kluge's study on gaming and algebra (Chapter 6), we can identify discontinuity and lack of transfer (in a broad sense). *Reflection* is connected to emerging awareness of what different contexts or practices offer about perspective making and the opportunity to see one's own world through the eyes of others; i.e., perspective taking. Rasmussen's study (Chapter 4 in this volume) of how microblogging is used to re-enact diverse perspectives on "nationalism" in history is one such example. *Transformation* is the fourth mechanism, which involves going beyond existing practices and producing a new boundary practice. All the contributions in this section demonstrate such dimensions, but they are particularly visible in Kumpulainen and Mikkola's case (Chapter 2), where bicycling is connected to developing citizenship, and in Rasmussen's case of transforming classroom traditional talk into orchestrated and collective conceptual reasoning mediated by specifically designed technology (Chapter 4). In sum, these mechanisms demonstrate how boundary work does not only involve different types of bridging, but also how discontinuities in action and interaction emerge and at the same time function as resources for development.

Most of the studies referred to by Akkerman and Bakker (2011) concern boundaries within or across work contexts. There are few that focus on boundaries within school, and the few that exist tend to center on diverse discourses and hybrid language practices (Gutiérrez & Rymes, 1995, is one classic example, and Brevik's Chapter 3 in this section serves as another). The contributions in this section take boundary crossing within school into new territory and disclose new activities and practices where digital technologies mediate learning. This amounts to a potential expansion of the original learning object, or expansive learning (Brown & Cole, 2002; Engeström, 2015; Engeström & Sannino, 2010). Expansive learning is not only concerned with acquiring existing or accumulated knowledge, but also with "increasing learners' capacities to expand and go beyond what they already know…to understand and produce new and situationally relevant knowledge" (Ludvigsen, Lund, Rasmussen, & Säljö, 2010, p. 2). Such expansion is connected to transformation of the learning object as various perspectives inform the boundary work and with digital technologies as mediators, as well as an extension of the physical and social world. All the contributions in this section share such perspectives on technologies. Consequently, digital technologies as artifacts need to be further examined before we can fully understand the roles they play in bridging and boundary work.

Digital and Networked Technologies: Mediator and Medium

An artifact is a socially produced contextual resource that embodies knowledge, perspectives, and practices. Thus, artifacts can be conceptual, linguistic, symbolic, and material. Equations, the alphabet, the periodic table, ploughshares, and computers are all examples of such cultural-historical resources. Artifacts embody collective insights developed over time and attain significance as gatekeepers to cultures, connect persons within and across cultures, and also hold the potential to transform cultures and practices, as such technologies can potentially link minds and hands (and hearts!) since they suspend constraints in space and time (Lund et al., 2014). In education, we see how the relationship between digital technologies and learning have increasingly been linked to theoretical analyses and discussions of learning (Koschmann, 1996; Säljö, 2010). Researchers have observed how the conceptualization of what knowledge is (ontology) changes, as well as the assumptions of how knowledge can be acquired (epistemology) (Shaffer & Clinton, 2006).

But as artifacts, digital technologies have been intimately linked to the principle of mediation; they are conducive to agents constructing their collective objects. Consequently, they are sometimes referred to as tools or instruments. However, as Turkle (1995) showed, digitalized reality is not just mediating means, but actual spaces to inhibit and where identity formation takes place. More recently, this approach has been pursued by Rückriem (2009), who sees "the Internet as a basic transformation factor" and "as a framework for perceiving our present reality as a qualitatively new emerging social formation" (p. 95). Drawing on media theorist Michael Giesecke, Rückriem posits that new media give rise to new epistemologies and that "New worldviews emerge, and the position of humans in relation to the world gets reformulated" (p. 96). Such reformulation can also be termed re-contextualization, a theme that runs through many of the contributions in this section and points to bridging as involving competing or co-existing epistemic positions, perhaps one of the most challenging aspects of technology-rich boundary work and hybrid practices.

Several scholars have found strong correlations between teachers and student teachers' fundamental assumptions about learning and ways of approaching technologies (Aagaard & Lund, 2013; Jimoyannis & Komis, 2007; Sime & Priestly, 2005). As Jimoyannis and Komis (2007, p. 152) summarize: "A series of independent studies indicate that both teachers' personal theories and perceptions about teaching and learning processes and their level of competence with ICT play a major role in how they implement ICT and how they motivate themselves to use ICT tools in the classroom." Also, the technological development can make perspectives about learning visible that may otherwise remain abstract. For example, we can consider the use of technologies in relation to behaviorist drills and exercises, cognitive problem solving, collaborative learning, work on simulations and models, or knowledge construction. Learning theories can thus be made visible and become the

subject of discussion. The implications are that, even though digital and networked technologies may come with certain inscriptions or dispositions for intended use, there are a number of variables involved, including the learning object, the task design, teachers' orientations, curricular affordances, and assessment criteria and practices that exercise strong and durable bearings on what is actually possible to achieve or alter in institutional contexts for learning and teaching. Still, the potential ICT carries for the transformation of practices by connecting agents, contexts, and practices points to its vital role in bridging. Many of the contributions in the present section clearly demonstrate how the combination of agentive teachers and digital technologies amounts to such transformation and expansion.

Finally, it is important to point to some problematic issues that arise when pedagogy meets technology in the classroom. One is classroom management and a view of technologies as disruptive and detrimental to focusing on learning objectives (Krumsvik, Egelandsdal, Sarastuen, Jones, & Eikeland, 2013). Blikstad-Balas (2014), for instance, shows that, when pupils in the final year of upper secondary school (in Norway) are given access to digital technologies and the Internet, they spend a disproportionate amount of time on non-scientific activities, such as games, Facebook, online newspapers, and aimless surfing. Similarly, Elstad (2006) found that a lack of teachers' presence and a laissez-faire approach to ICT resulted in accountability failure. These are all indicators of discontinuity when trying to connect schooling and traditional practices to out-of-school and novel or expansive practices involving technologies.

A Matrix of Contributions

So far, the contributions in the present section have been connected to trends and categories identified in scholarly literature. However, in order to better perceive the many types of bridging and their attributes, Table 1 seeks to—at the risk of being overly simplistic and reductionist—summarize some of the components and variables found in and across the studies. The aim is to better identify some of the more generalizable qualities (in the sense discussed above) found in this material. The table should be read as a topological map of the five chapters and six cases that constitute section 2.

DISCUSSION: ANALYTICAL GENERALIZATION

Knowledge developed in specific contexts is not always easy to translate into general insights; there are simply too many variables that apply to persons and contextual resources in even the most transparent activities. Table 1 is such an example. However, if we were not able to de-contextualize particular insights from one context and re-contextualize them in others, development would not occur and collaboration across perspectives and settings would not be worth pursuing. Also, challenges and problems that go beyond local contexts would be impossible to take on. One way

Table 1. Overview of the cases in the five chapters in part i of this book

Chapter	*2 (case a) Kumpulainen & Mikkola*	*2 (case b) Kumpulainen & Mikkola*	*6 Kluge*	*5 Furberg & Dolonen*	*4 Rasmussen*	*3 Brevik*
1. Learning object	Making a school musical	Developing citizenship	Learning algebra	Understanding the function of vital organs in the human body	History and understanding various perspectives on nationalism	Developing reading skills in English; poor readers in L1, good readers in L2
2. Unit of analysis	Activity systems	Activity systems	Recurring patterns	Classroom dialogues	Video-recorded dialogic interactions	1. Questionnaire for L1/L2 patterns 2. Pupils' individual perceptions
3. Agents involved	Pupils as producers; elementary level; teachers bridging within and across curricula	Pupils as explorers; upper secondary school; teachers with transformative agency bridging subjects, expertise, and contexts; expert communities	Pupils as problem solvers; primary (PS) and lower secondary school (LSS); dyads; teacher scaffolding; mixed ecology of learning	Pupils engaged in dialogical processes involving conceptual sense making; primary school; teacher bridging conceptual and procedural support, social regulation, and resources	Pupils and teacher in collaborative dialogue; upper secondary school; teachers as co-designers of new technological and pedagogical opportunities	Pupils connecting life world practices to schooling; upper secondary school; teachers as potentially connecting contexts
4. Competencies involved	Creativity, multimodal practices, multiple discourses; individual and collective agency; socio-emotional engagement	Handling demanding future situations; exploratory interactions; critical thinking; individual and collective agency	Solving equations ("Bike racing") and symbol manipulation, and activating algebraic rules ("DragonBox")	Conceptual sense making; making different resources relevant for learning objects; inquiry-based learning; deep learning	Subject-specific dialogic skills; summarize, argue, and make claims; collaborative skills	Complex reading and extended social interaction (oral and written); media and ICT literacy; advanced L2 vocabulary

5.	Technologies involved	One-to-one PCs ("Netbooks") connected to the Internet, and a collaborative writing tool with a chat channel	Mobile technologies; interactive maps; social media	Digital games: "Bike racing math algebra" (PS) and "DragonBox" (LSS); control group using the "Kikora" tutoring system	Digital whiteboard and iPads; digital text-based resources: scientific articles and digital textbooks; digital representations: animations, diagrams and simulations	Handheld devices; specially designed microblog applications ("Socius," "TalkWall"); interactive whiteboard	Computer games, a variety of media in L2
6.	Contexts involved	Formal (school) and informal (pupils' life worlds)	Events across time and space and on the move (bicycling)	School and pupils' life worlds	Classrooms; structured teacher support	Classroom and ICT-mediated historical simulation	School and out-of-school gaming
7.	Vital concepts	3rd space; hybridity; boundary crossing; transformative learning; identity formation	Navigation; hybridity; transformative learning; inquiry-based learning	Engagement; transfer as intrinsic integration	Conceptual and procedural teacher support; technology-based learning	Dialogic; inter-thinking; co-construction; microblogging; appropriation;	Reading comprehension; agency; re-contextualization
8.	Type of bridging	Connecting learning spaces (school, home, local community); epistemologies	Navigating a wide range of contexts across both time and space, including expert communities; epistemologies	Connecting learning spaces and epistemologies; discontinuity identified among LSS pupils due to conflicting goals/ practices	Teacher connecting individual, group, and whole-class activity; material and social support, multiple resources; mixed learning resource ecologies; epistemologies	Connecting existing practices to future practices, past events, and new opportunities; individual and collaborative (shared) reasoning	Competency in L2; media and digital technologies bridging life worlds and schooling; discontinuity identified connected to school relevance of gaming and identity issues

of approaching this problem is to identify local empirical carriers of deeper and generalizable principles, to examine the relationships between particularization and generalization (Ludvigsen et al., 2010). These will constitute the reasoned judgment or assertational logic that constitutes analytical generalization; i.e., "the extent to which findings from one study can be used as a guide to what might occur in another situation" (Kvale, 1996, p. 233).

Using Table 1 as a rudimentary backdrop and lens (readers are urged to consult the separate chapters for their rich detail), the present chapter seeks to identify generalizable elements that amount to principles that can be de- and re-contextualized. It must be emphasized that the matrix, as well as the interpretations and ensuing meta-analysis of the contributions, is the sole responsibility of the present author, although authors of the separate chapters have been consulted as to the validity of my analysis.

Transformative Agency

Starting with the first two rows in Table 1, one immediately notices the extreme diversity in school subjects or domains and the tasks that learners (and teachers and others) are facing. We encounter the production of a musical, developing conceptual understanding in social studies and natural science, and more specific school subject skills, such as doing algebra or developing reading proficiency in L2 (English). Also, these activities and tasks are dispersed over the whole continuum of primary and secondary school levels. This variety is also reflected in the units of analysis (second row) used in the separate studies. We encounter activity systems at a macro level, cohorts on a meso level, and interactions and interviews on micro-level activity. Thus, the empirical data constituting bridging in its many shapes reflect a broad educational spectrum and are not restricted to a particular domain, grade level, or level of analysis. This testifies to the wide-ranging possibilities of bridging.

Bridging is not a passive endeavor. In the third row, we encounter the agents and their involvement in bridging activities. A common denominator for the pupils involved is their transformative agency, though to varying degree. Transformative agency involves encountering a problem, a challenge, a dilemma, a double bind, or alternatives (commonly referred to as stimulus 1, S1) and making use of a series of available cultural resources (commonly referred to as a series of stimulus 2, S2) in order to bring about a way forward (for extended discussions, see, e.g., Lund & Eriksen, in press; Sannino, 2014). This Vygotskyan principle places agents in a role where they do not merely respond to a situation but actively draw on resources that can be accessed in order to influence or transform it. In the contributions listed in Table 1, we see how such transformation involves becoming producers and explorers, engaging in problem solving and conceptual sense-making, and co-constructing knowledge—all roles that break away from more traditional roles for pupils as individual consumers of knowledge, exposed to rote learning and tasks that only engage short-term memory.

Transformative agency is further specified in the fourth row, where required and enacted competencies are listed. These competencies match many of the 21st-century skills, such as creativity, decision making, collaboration, and digital literacy.[1] Thus, there is a future-oriented quality to these pupils' transformative agency. Still, Chapters 5 and 8, which have computer games as a common denominator, demonstrate that competencies and agency do not necessarily move from one context to another; we see clear examples of discontinuity in both cases and a need for teachers to help pupils make connections (cf. discussion on types of bridging below). It is worth remembering Kumpulainen and Mikkola's point that students can react negatively to the use of technologies and media in formal education, what they may perceive as the teachers' attempts to colonize their free-time domains (Chapter 2 in this volume).

But the issue of transformative agency is even more visible when we look at the roles of teachers. One striking commonality is the agency exercised over or with digital and networked technologies (and other resources). The teachers we encounter in these studies do not relate to technologies as "given" but as a multitude of resources that can be made relevant for educational purposes through designs of learning environments and trajectories. Thus, these teachers are bridging a multitude of school subjects and themes from relevant contexts (and, consequently, diverse epistemologies). See, for example, how the teacher in Rasmussen's study adopts a *dramatis personae* in order to enact scenarios and frame a historical issue as technology-mediated roleplaying. By developing and enacting designs, teachers find themselves in a variety of supporting roles, from co-designers and facilitators to more authoritative presenters and providers of input. We see how these teachers seek to balance and bridge perspectives across space as well as time—a strong indicator of what future teacher education should foster to a greater extent.

Bridging as Polycontextuality

Educational activities have always included an array of artifacts to make phenomena and subject matter visible. In all the chapters of this book, we see how traditional analog artifacts (e.g., textbooks) still have a role to play. However, as row 5 indicates, multiple and diverse digital technologies are put to use in the various cases. Broadly, they fall into two categories: technologies that make collaboration and networking possible and technologies that function as representations of subject knowledge, concepts, or principles. In both cases, they extend the immediate learning environment and open up new opportunities of learning. But as briefly noted in the discussion on technologies, they are not only mediating artifacts; networked technologies and games also function as places to *be* and to *become*. Traditional learning resources such as textbooks are "closed" and authoritative in the sense that they capture aims and competences given in a syllabus. Some digital resources also cultivate such aspects, e.g., tutoring systems. However, in most of the digital resources encountered in the cases, the digital resources are "open" in the sense that they are less prescriptive and authoritative, and function as connectors. Also,

they do not necessarily carry a particular disciplinary discourse. Thus, pupils are confronted with bridging the educational aims of schooling with the many contexts that the "open" resources represent (Rasmussen & Lund, 2015). These contexts are listed in row 6.

When we look at the contexts involved, school is nearly always an important locus for educational activities. However, a closer look reveals that there are multiple contexts involved, such as spatial, temporal, social, virtual, and cognitive. The implication is that agents need to develop a sense of polycontextuality (Engeström et al., 1995; Lund, 2006) in order to traverse them. Thus, one striking attribute to the studies referred to in the present section is the way bridging exceeds boundary work across physical settings or sites, although these are always present. But we also encounter bridging across perspectives and dimensions that pertain to epistemological positions and knowledge logics. Playing a computer game involves different epistemic work than co-constructing concepts or appropriating insights from taking field trips or engaging in arts and crafts. This is where bridging becomes much more challenging than establishing boundary zones and leaving the boundary work to pupils. Also, there is a risk of "romanticizing" polycontextuality in the sense that a synthesis of epistemologies should emerge. The cases on gaming (5 and 8) demonstrate that pupils do not automatically connect the different epistemologies involved (how they learn to solve a problem in the game vs. how to de- and re-contextualize the principles to better understand and appropriate the school subject). The question that arises is whether bridging should entail making epistemological discontinuity an essential element. This is a question that has haunted teacher education for decades and a look at how academic knowledge and experiential knowledge may not—at least for the student teachers—add up to a coherent perspective. An alternative way of approaching different epistemologies is to demonstrate and discuss how they may be mutually constitutive for learning and development. The contributions discussed here provide ample opportunity for pursuing such an alternative. However, this will be a major challenge for teachers—an issue of vital importance for how to make bridging productive (see, e.g., Rasmussen, Chapter 4, and Brevik, Chapter 3, but also indications in the other chapters), but which is beyond the scope of the present chapter (but see, e.g., Konkola et al., 2007 for a discussion of teachers as brokers between contexts; this issue will also briefly be addressed in the conclusion).

Conceptualizing Bridging

Closely connected to the issues of agency, technologies and contexts are the conceptualization of what is going on in the various cases. Related but still different concepts are used in order to capture what is going on and with what implications. Also, concepts add up to a perspective where the point is not to establish a one-to-one correspondence between a theory or model and the world, but how we identify concepts and theoretical approaches that have explanatory power when

facing a challenging phenomenon or practice. Such conceptualization validates the case in question beyond a status as mere illustration or example and adds to the generalizability of the situated experience. Looking across the cases, three concepts of bridging stand out: spaces for polycontextual or hybrid practices, transfer in the sense of de- and re-contextualizing knowledge across contexts, and collaborative approaches to knowledge construction. The common denominator for these concepts is transformation—of practices but also of agents involved. Some of the contributions discuss issues of identity when engaging with multiple learning contexts—how you develop an identity in a community of practice but also how you are torn between identities recognized with practices in specific contexts. Thus, transformation in a broad sense emerges as a crucial concept for both understanding bridging as well as designing learning environments and trajectories that bridge polycontextual activities.

A Typology of Bridging

When subsuming rows 1–7 under a tentative typology of bridging and applying it to the separate contributions, some characteristics emerge.

A number of the cases center around *spatial bridging*, especially 4a, 4b, 5, and 8. In these cases, connections are reminiscent of traditional boundary crossing and boundary work where competencies and practices in one context, typically out of school, such as local community or lifeworld experiences, are sought to be made relevant and productive in an in-school context. The insights provided by these contributions may prove especially valuable as teachers increasingly work on multi-cultural and proficiency-heterogeneous classes. However, in some of the cases, bridging does not involve more than the school context but extends to other dimensions.

A second category that emerges is *temporal bridging*, especially cases 4b and 7. Here we see how current and past well-established practices are sought to be connected to future-oriented and innovative practices, in line with competences identified as crucial for the 21st-century's knowledge society. It is interesting to see how shared reasoning, knowledge on the move, and connections with expert communities appear in these cases. It is also interesting to see how these practices are aligned with competences (including social and emotional) for the school of the future as envisaged by the Norwegian Ludvigsen committee (Ludvigsen-utvalget, 2014, 2015).

Bridging as connecting the individual to the social is also a recurrent theme. For instance, in Rasmussen's study (Chapter 4), we see how pupils can project their individual perceptions of concepts or subject-related issues in a way that makes them visible for peers and teachers and, thus, made into shared objects for further discussion. In Furberg and Dolonen's study (Chapter 5), we see how the teacher plays an important role in bridging individual, group, and whole-class activity according to what is at stake or what is the aim. However, Kumpulainen and Mikkola's study

(Chapter 2) of how young pupils produce a musical shows that the whole effort rests on a collaborative timeline from planning via writing, making animations, and performance. This is a particularly rich picture of how an array of cultural resources connect agents and activities toward a co-constructed object.

At the juxtaposition of spatial, temporal, and social bridging, epistemological issues emerge. The cases show how pupils (and their teachers, as well as others) engage in diverse meaning-making activities, leaving trails of how they come to knowledge. Discourses, practices, use of cultural artifacts and information, and the social organization of agents are all expressions of epistemic work, and these contributions reveal how demanding such work is when multiple contexts are involved. Examples are found in, e.g., bridging formal and informal epistemic positions (Chapter 2), bridging knowledge logics found in games with logics found in school subjects (Chapters 3 and 6), bridging epistemologies in scientific disciplines and school subjects as well as between conceptual and procedural learning (Chapter 5), and bridging historical and current perspectives on nationality (Chapter 4). In addition, all cases show dimensions of individual and collaborative epistemic work.

However, the contributions also demonstrate how bridging does not reach its full potential. The clearest examples are in the two studies of gaming in arithmetic and English as L2. The interesting thing is that there are indications of pupils' success in re-contextualization of their competences developed through gaming despite the fact that they do not see or perceive the connections. In Chapter 5, we learn that pupils "fail to see the logic of the operations" or "they find the logic to be unpredictable and (…'strange')." Intrinsic integration seems not to materialize for them since the goal of the game and the goal of learning are not aligned. Still, despite such discontinuity, pupils demonstrated "remarkable" engagement and activity. Similar potential was detected in Chapter 3, where learners, despite proficiency displayed in L2 in school, did not make the connections to gaming, even if they recognized this context as conducive to learning English. As one of the pupils put it, "I don't feel it is related to school, even if I learn a lot of English." Others concur, pointing to the fact that school would have to offer similar contexts for them to more actively demonstrate their proficiency, e.g., in vocabulary and phrases. This emerges as a challenge for teachers' bridging competence and agency.

CONCLUSION: WHAT NOW?

When we look at the chapters not just as separate studies, but also across in order to identify how cases demonstrate successful bridging as well as unfulfilled potential, one is struck by the complexity involved. Bridging and the many forms of boundary work show that this is far too demanding to leave to pupils alone to handle. Still, there are so many opportunities offered by polycontextuality that schools can risk becoming marginalized if they opt for hegemonistic and no-lateral

relations to other potential contexts for learning. They risk burning bridges instead of building them.

We have seen that bridging can be understood as making spatial, temporal, social, and cognitive connections. Successful bridging also requires transformative agency and a view of technologies as artifacts, as well as environments where socialization and identity formation take place. There are some serious implications for teacher education, as well as for the professional development of practicing teachers. It would seem that successful bridging is very much a matter of teachers designing extended learning environments and trajectories where cultural resources and potential polycontextuality form the core of the design together with the learning object. Elsewhere, the notion of design has been developed in some detail (Kaptelinin & Nardi, 2006; Laurillard, 2012; Luckin, 2010; Lund & Hauge, 2011), but not with a focus on bridging contexts in the sense done in the present chapter.

In previous studies of design, as well as in the present section, the teacher as designer of bridging and the teacher as a broker or negotiator emerges. The increased complexity of the practices and the required understanding of the epistemological issues at stake call for unusually capable teachers who can design tasks as boundary objects, orchestrate learning activities, make relevant cultural resources available, and assess competences and learning outcomes we have just begun to see the outlines of. As Brevik observes in Chapter 8, in this way, we can build on students' strengths instead of mainly repairing their weaknesses as isolated traits. Also, such an effort is necessary if schools are to tap into the many social and material resources that abound and retain their ecological validity in a quickly progressing knowledge society.

NOTE

[1] For a comprehensive overview of 21st-century skills, see http://www.p21.org/our-work/p21-framework

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PART II

GAVRIEL SALOMON†

Cattle die, friends die,
Every man is mortal:
But I know one thing that never dies,
The glory of the great dead.
(From Hávamál)

GAVRIEL SALOMON†

8. IT'S NOT JUST THE TOOL BUT THE EDUCATIONAL RATIONALE THAT COUNTS[1]

TECHNOLOGY—THE PROMISE

Massive open online courses (MOOCs) (Kop, 2011); bring your own device (BYOD) (Song, 2014); advanced learning analytics (Baker & Inventado, 2014); hybrid, blended and disruptive educational environments; networks of connected learners (Siemens, 2014); blended learning experiences (Pedaste et al., 2013); simulation-based inquiry learning (Mulder et al., 2014) with virtual manipulatives (Zacharia & de Jong, 2014); and a multitude of educational apps popping up daily (Cherner, Dix, & Lee, 2014)—these instances of technology loom so large in prevailing visions of education that the role of education as the driving force of their design and utilisation becomes lost. This essay presents an attempt to balance the picture in which I synthesise ideas from earlier articles I have written (Salomon, 1994; Salomon & Almog, 1998). There is the danger that these arguments might sound trivial and self-evident, but we hope that they will stabilise us as we walk the tight rope between technocentrism and pedagogy (Gash & McCloughlin, 2015), between the science of what can be done and the vision of what should be done.

Education is considered a medium for cultural transmission (Ballantine & Hammack, 2011), the acquisition of desired knowledge (Bereiter, 2005) and the cultivation of needed skills. Indeed, I concur with Biesta (2009) that the three domains of educational purposes—qualifications, socialisation and subjectification—are always at stake in educational practices whether we intend it or not. Although the relative balance between the three domains might vary, Biesta's (2009) main message is that a one-eyed approach might have unforeseen consequences for the overlooked domains. Perhaps due to the crucially important role of the school in the education of our young, there seem to be constant and often justified complaints about the sad state of education and the need to improve, renovate and overhaul it. Such complaints prompt a dedicated search for quick solutions, magic wands and wonder tools. An especially influential idea is that technology can solve deep, serious problems in education.

This flawed thinking, referred to as technological solutionism by Morozov (2014), is clearly evident in the history of innovation in education. First, educational radio, then film and the teaching machine, followed by instructional television

E. Elstad (Ed.), Educational Technology and Polycontextual Bridging, 149–161.
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were supposed to be remedies for all educational malaise (Cuban, 1986). Then, all of a sudden, a new gizmo arrived on the horizon: the Computer, promising to revitalise, even redo education (Cuban, 2009). The moment the first personal computer (PC) ran off the assembly line, it commanded great attention. This is an interesting thought: one of the first brands of PC was the Apple. This is a most suitable name for the computer, for like its biblical predecessor, it immediately became an irresistible, most tempting fruit and the ultimate solution for all educational malaise. This, to an important extent, continues to be its fate today. The modern computer in its many shapes and forms—laptops, iPhones, iPads, Apple Watches—with its apps, Internet access, social media, and multimedia, with its model-building, simulation and gamification capacities, with its chat, email, hypertext and other unfathomable possibilities, seduces us into believing that it can do miracles in schools and other sectors of society.

The introduction of the computer for learning purposes in classrooms, colleges, homes and workplaces has been expected to cause major shifts in education. The promise of technology for education lures school districts and states to invest heavily in the newest gadgets—decisions often rash, misplaced and misconceived. The same story is told again and again and again. Just consider the scandalous iPad initiative in cash-stripped Los Angeles (Newcombe, 2015). The intention of the now-aborted $1.3-billion project was to provide an iPad to every student, teacher and campus administrator in the second-largest school district in the United States. More than 40,000 iPads preloaded with the Pearson curriculum were purchased. Later, though, the district accused Pearson of providing an underwhelming product beset by technical glitches, and consultants concluded that few teachers even used the Pearson software. The bidding process that led to the original contract has become the subject of a Federal Bureau of Investigation enquiry. Rash, misplaced and misconceived, the ambitious plan now looks spectacularly foolish.

Scholars have described the computer as a subversive tool (Salomon, 1993b; Squires, 1999), a Trojan horse whose belly is filled with new educational philosophy and pedagogy which will unfold more or less on its own the moment it is brought into real or virtual classrooms. In fact, as Harris so succinctly points out in a 2005 editorial in *Contemporary Issues in Technology and Teacher Education*, the rhetoric about educational technology demonstrates a basic confusion of technology integration—the pervasive and productive use of educational technologies for learning and teaching purposes—and the use of technology as a vehicle of educational reform (Harris, 2005). One notion does not necessarily imply or require the other, especially in democratic societies that value ideological diversity. Impressing with areas of society in which the impacts of computing and the Internet are most notable, technological determinism has been allowed to gain supremacy. What impacts is it likely to have on education?

TECHNOLOGY—SHORT AND LONG-TERM IMPACTS

Any technology has at least two kinds of impacts: a gradually accumulating but eventually profound impact on society and a faster, more immediate and hence more visible impact on particular practices. The former usually constitutes an unforeseen and slowly building impact. We call it the drip effect of technology, whose nature becomes clear only after a while, usually a very long while. Examples are the development of suburbia and the revolution in sexual mores as a result of the automobile or changing patterns of interpersonal communication as a consequence of email. Nobody intended these effects, nor did anyone think them out; they happened more or less all on their own, driven primarily by economic and efficiency considerations that capitalised on the new opportunities afforded by technology. What is technologically possible becomes implemented and, thus, becomes desirable.

In contrast, there are more immediate, focused and usually deliberate impacts on such practices as science, architecture, medicine, commerce and banking. Can you imagine today's stock market without computing, book sales without Amazon or your daily interactions with the world without social media, chat or texting? Such changes capitalise on what technology affords, but unlike the previous effects, these are focused and intended. Neither banking nor libraries, neither shopping nor the training of pilots has been changed unintentionally as a side effect.

Of course, in reality, the effects of technology do not divide so neatly into two separate categories: unintended, long-term effects become desired and intended, and intended ones have their own unintended side effects (Christensen, 2002). It has gradually become increasingly clear that education has been and is being affected by the unintended, drip-like effects of the opportunities afforded by ever-spreading high-speed broadband accessibility. In fact, certain claims ring increasingly true: that, whether the educational establishment likes it or intends it, major changes will take place, such as the gradual disappearance of the school building, the textbook and the flesh-and-blood teacher. A decade ago, a former colleague, a very thoughtful sociologist of education, predicted that schools will gradually disappear, and those remaining will serve a small, rich elite (Papert, 1980). We are perhaps not quite there yet, but the increased availability and quality of free MOOCs certainly makes us wonder if my colleague might be right after all. Unintended, long-range effects become desired and intended.

Turning to more immediate, focused and intentional changes, we can see how the whole worlds of commerce, medicine, communication, design, travel and, most interesting to us, higher education are rapidly undergoing major changes (Bowen, 2015). These are deliberate, intended changes, making use of the best that technology can offer. Do similar processes occur in other realms of education? Has formal education experienced such effects? Has education finally seen the equivalent of

a Model T Ford? Has it experienced a revolution similar to the introduction of the tractor to farm work? Has it seen any profound changes that go beyond doing more or less the same things only a bit faster, happier and with more colour? No, not really. Not on any reasonably large scale, at least.

DISAPPOINTMENTS AND THEIR REASONS (I)

Indeed, the truth is that, by and large, history keeps repeating itself (Cuban, 1986, 2009). So far, very little, if anything, has happened in education as a result of computing. Are then our expectations and, consequently, the financial investments in educational computing justified? Is it reasonable to expect educational computing to have a profound, positive impact on education? Or is all this no more than fantasy and wishful thinking? Indeed, why do we witness profound effects on, say, advertising, medicine and travel but not formal education? What in education successfully resists any major changes? Numerous answers have been offered (Scardamalia & Bereiter, 2015), blaming the conservative nature of education, its need to maintain an updated façade without really changing, and more.

We would like to add two pennies' worth of thoughts on this matter. In my opinion, three factors are involved here: the technological paradox (or the rule of trivialisation), the technocentric focus (or how omnipotence turns into impotence) and misguided research (or how not to learn from past experiences). To an extent, these three factors represent different takes on the same issue and complement each other.

The first factor, the technological paradox, results from the consistent tendency of the educational system to preserve itself and its practices by assimilating new technologies into existing instructional practices. Technology becomes domesticated, which really means, that it is allowed to do precisely and only that which fits into the prevailing educational philosophy of cultural transmission. According to this implicitly espoused philosophy, there are those who know and those who don't, there is a body of important knowledge that all must master, and mastery comes through acquisition, internalisation, rehearsal and digestion. It is, of course, acknowledged that learners differ from each other, so knowledge ought to be transmitted in bite – sized bits that fit each learner's channel and digestive capacity. According to this view, knowledge can be transmitted, and the role of technology is to assist in this process (Greeno, 2011). Hence arises the development of drill-and-practice programmes, courseware and such, which until recently have dominated the use of computers in schools. Students are to learn from this technology, but its uniqueness as a tool of construction, communication and design to learn with—not from—is suppressed (Mulder et al., in press). No one wants to upset the prevailing practices by rocking the educational boat.

The paradox is that a highly powerful and innovative technology is taken and domesticated so that it does more or less what its predecessors have done, only a bit faster and a bit more nicely. Consequently, nothing really happens, which proves

what sceptics have argued all along and what misguided research tends to show: technology makes no difference in learning. Of course, it cannot make a difference as it has been domesticated to be completely subservient to the on-going practices. Emasculated tools cannot do any harm, but they do not do any good either.

DISAPPOINTMENTS AND THEIR REASONS (II)

The second and most important factor is the technocentric focus. Leaving aside the technological paradox and turning to elements in education that want to see a change, it appears that they entertain the expectation that computers will bring about change all on their own.

I have recently read numerous rationales, descriptions, prescriptions, recommendations and visions for MOOCs in higher education and BYOD in secondary education (Kop, 2011; Song, 2014; Baker & Inventado, 2014; Siemens, 2014; Cherner, Dix, & Lee, 2014). Most expositions I have encountered have a common point of departure that is the basis for all the rationales: what MOOCs or BYOD can accomplish. Hardly have I ever found a paper that starts out from the perspective of learning. Technology is the beginning and the justification for all rationales. What is possible becomes desirable! Interestingly, this technocentric approach is taken not only by technophiles but also by teachers (Harris, Mishra, & Koehler, 2009) and students (Brennan, 2015). The technology needs to be mastered as an end in itself, not as a means for the acquisition of something greater, such as knowledge or social skill. Teachers at one of our better training colleges in USA were taught a new (constructivist) pedagogy and the technology that helps realise it in real-life classrooms (Keengwe & Onchwari, 2012). Students were given the opportunity to experience first-hand a constructivist, team-based, problem-oriented, technology-intensive pedagogy. When asked what the most significant thing that they had experienced and learned was, though, they reported that it was the use of iPad (Cochrane, Narayan, & Oldfield, 2013). Pedagogy was rarely mentioned. Not knowledge but the iPad becomes the centrepiece! Why? Because, as I stated at the beginning of this essay, the iPad, like the biblical apple, commands much attention as it is far more tempting than a new approach to teaching. More specifically, mastering technology promotes one's self-esteem and perceived self-efficacy, whereas mastery of the new pedagogy arouses uncertainty (Pajares & Schunk, 2001). Little wonder, then, that this seductive tool is expected to produce results all on its own. Indeed, one may ask: are we not aware of computers' long-range drip effects on society, commerce and communication? Don't they take place quite automatically without much doing on the part of anyone? Should not education be so lucky as to experience the same? The answer is that it might, but this is not an especially useful attitude to entertain for at least two reasons. First, drip effects on society are long term, and education cannot justifiably sit and wait for them. Second, and far more importantly, these long-range effects are unintended. There can be all kinds of unintended effects; some might even be educationally interesting, but many might not. Only recently

have we learned from Biagi and Loi (2013) that education is not in the business of producing unintended and unknown effects; it is designed to achieve well-intended, positive outcomes.

Others may argue, and do so quite forcefully, that we should not wait for some unknown and unintended effects but, instead, join the technological bandwagon and, as they call it, 'move with the times'. Consider more specifically the case of higher education. It is claimed that higher education as we know it, fortified as it is in its ivory towers, can become increasingly less costly and more virtual, democratic and egalitarian. Its three functions—the preservation of knowledge, production of new knowledge and transmission of knowledge—can easily be replaced by MOOCs, always accessible, for all, from everywhere. An example of a popular MOOC is the course Digital Marketing Channels: Planning developed by the University of Illinois at Urbana-Champaign and offered via Coursera: 'Discover the multiple channels used by digital marketers today and how to leverage them optimally. Interact with content and hear from industry experts invited to join the course' (CourseBuffet, 2015). The same applies to the spread of virtual research communities which span the whole globe and, of course, to teaching, a labour-intensive activity that can be replaced easily and cheaply by on-line courses.

Have we reached the Garden of Communicational and Educational Eden when we fully embrace virtual instruction? Once we all join the technological bandwagon, equally high-quality education will be attained. This, in my view, is the peak of technocentrism; it completely ignores crucial social and human factors. Without taking these into consideration, MOOCs—as one example of technocentrism—are in danger of yielding only virtual results. Indeed, this can be witnessed by the pitifully small percentage of students who actually graduate from MOOCs with real degrees. Not many students have the self-discipline or the sustained motivation to be virtual learners: student dropout rates from MOOCs are typically 85%–95% (MediaCore, 2015).

At this point, permit me to deviate for a few moments to elaborate one such human factor, which raises questions of the centrality of technology in the acquisition of knowledge. Herbert Simon made an important observation in 1998: he claimed that the concept of knowledge, which until now has been taken as a noun denoting possession, is gradually becoming a verb denoting access (Simon, 1998). It is less and less important what you carry in your head for eventual use in the future; it becomes far more important what information you can access when desired and what you know to do with it. Knowledge, thus, changes from an object-like entity hoarded like valued goods to an activity of instrumental utility. Simon's (1998) observation implies an important distinction between access to information and the knowledge that guides and results from such access. The growing emphasis on access to information and the processes of selection and integration that it implies compel us to distinguish between information and knowledge. Information encountered and

accessed is not the same as knowledge constructed based on it. Information is not knowledge. Perhaps for this reason, we talk of the information highway and the information age, not the knowledge highway or the knowledge age.

What are the differences between the two?

- Information is discrete; knowledge is arranged in networks with meaningful connections between the nodes.
- Information can be transmitted as is; knowledge needs to be constructed as a web of meaningful connections.
- Information does not need to be contextualised; knowledge is always part of a context.
- Information requires clarity; the construction of knowledge is facilitated by ambiguity, conflict and uncertainty.
- Mastery of information can be demonstrated by its reproduction; mastery of knowledge is demonstrated by its novel application.

This process of transforming information into knowledge is an intensive, purposeful process. Information items do not link to each other all on their own, except through sheer association. Connecting them requires at least tutelage and a community of learners. Regarding tutelage, there is no need here to explicate the importance of social mediation in learning. It is crucial to helping the individual transform information into knowledge, it serves as an external model and supervisor of yet-to-be-developed self-regulation, and it sustains motivations are sustained in the face of competing motivations. I once tested the extent to which an intelligent computer program can serve as a more capable peer in students' zone of proximal development (Salomon, Globerson, & Guterman, 1989). It can, but—for whatever reason—it is no match for a human tutor and lacks almost everything we include in the concept of human touch.

This lack relates to the second factor—a community of learners (Perkins & Salomon, 2012). Again, there is no need to reiterate here the importance of the interpersonal component of learning. We have increasingly clearer understanding of the importance of socially distributed cognitions and socially appropriated knowledge as indispensable, fundamental elements of good learning (Salomon, 1993a; Salomon et al., 1989). MOOCs try to replicate the functions of tutelage and community, but it is questionable whether virtual interaction truly functions as a collaborative tool as it usually does not afford the creation of shared beliefs, values and deeper knowledge.

As creatures, we are quite stingy in the expenditure of mental effort. Frequently preferring to mindlessly follow familiar routines (Salomon, 1983), we are often satisfied with raw information which yields inert, useless or ritual knowledge. This information masquerades as knowledge as it merely sits like a piece of useless wood or is mindlessly executed like a geometric, ceremonial dance. For, indeed,

seduced by the effortless gathering of data, we discount the costs of turning data into information, information into knowledge, and knowledge into wisdom (Harris, 1987). Here is where the technocentric approach misses the point: 'Schooling is not about information. It's getting kids to think about information. It's about understanding and knowledge and wisdom' (Cuban, 1993, p. 208). Whether information is transformed into meaningful knowledge or remains a collection of bits and pieces, like an assortment of screws and nails in a shoebox, heavily depends on numerous factors, in which technology plays a minor role. Technology can provide information, allow easy access, offer problems and simulations to be solved and provide means of traversing new multimedia routes or connecting students from three continents, but it cannot transform the information accessed into knowledge for students.

DISAPPOINTMENTS AND THEIR REASONS (III)

Finally, there is the third factor which, in my view, contributes to the disappointment with technology use in education as it reinforces technocentric tendencies: misguided research.

Research on new media is misguided in at least two ways. One way is apparent in the ubiquitous question: does the use of medium X produce better learning results than medium Y? Often, a technology-rich learning environment is set against a so-called traditional classroom. The second misguided way concerns the outcomes which we expect from new media and study. Hundreds, if not thousands, of studies perpetuate this horse-race paradigm—a paradigm condemned and sentenced to death years ago when discovery learning, educational television and computer-assisted instruction were compared with their traditional competitors. Now, it is MOOCs versus face-to-face classes, but it is still the same horse race paradigm. Neither Cronbach's (1967) idea of interactions with individual differences or with tasks and contents, nor Bronfenbrenner's idea of ecological context (2009) has had an impact on most studies. The horse race approach, which emphasises who runs faster and arrives first and which disregards aptitudes, tasks, contents and contexts, still reign supreme with the omnipresent conclusion of no significant differences. Of the 374 studies included by Russell (1999) in an overview of research on learners' use of computer-mediated communication and comparison with face-to-face communication, only 19 studies, that is 5%, showed any difference between the treatments; of these, a third favoured face-to-face (Russell, 1999). Notice that such research, pitting one medium against another with no regard for human and situational factors, reinforces the belief that it is the technology that makes the difference. The consistent lesson that it, in fact, does not seems to be continuously ignored.

The second misguided view pertains to the outcomes measured or observed. Say that we study a new learning environment, rich with technology, teamwork, authentic problem solving and the like. What do we end up measuring? By and large,

routine, traditional achievements. Why is doing so misguided in my eyes? Because different means, if they are powerful, serve different, not the same, ends. The greater the difference between the means is, the greater the diversity of outcomes that can be attained is. The technology with which we are concerned, powerful and different as it is supposed to be, is not merely another means for achieving the same goals traditional education has striven to achieve. Not that there is anything wrong with the three R's: reading, writing and arithmetic (or with the accumulation of college-level information). But the purpose of introducing high technology into education was not to do the same things a bit better, faster and cheaper. We wanted profound changes, not slight improvements. Imagine that someone in Europe at the end of the 17th century discovered electricity. It would have been a missed opportunity if the discovery were evaluated for its ability to light fires in coal stoves.

When novel, often constructivist and technology-intensive learning environments are designed, such as the Computer as Learning Partner project (Linn, 2014), then not only are old objectives attained, but entirely new goals become attainable. When we say that the Internet affords new activities, new experiences and new ways of encountering the world, we want to attain new goals, such as the ability to ask smart questions, work in teams, acquire lifelong-learning skills, construct higher-order knowledge and, perhaps above all, tackle new, complex problems in intelligent, creative ways. Considering only for the amount of information retained is stooping to the lowest-common denominator of attainments. Here is a modest example of a study we carried out to compare novel, constructivist classrooms and traditional ones. The point of the study was not to determine which environment is better but which is better for what purpose. As we found, traditional classrooms produced better mastery of recalled information, whereas more technology-intensive, constructivist classrooms produced better skills at formulating questions, generating hypothesis and intelligently tackling new problems.

Note how these two misguided research approaches reinforce the technological paradox and the technocentric approach. The paucity of convincing findings supports the view that the whole enterprise of tablets to school kids is not worth the investment, while the dominance of the digital medium in the horse-race approach to research reinforces the expectation that technology in and of itself will do the trick. The search for the same old kinds of achievements fails to reveal in what new ways technology can and does make a genuine difference.

IF IT AIN'T TECHNOLOGY, WHAT IS IT THEN?

So, if not technology by itself, what does make a difference in learning, and what role does technology play in this respect? Technology alone, as I have attempted to show, is but a trigger; it is an opportunity, an affordance. There are huge differences, though, among what technology can do, what it does in actuality and what, in our eyes, it should be doing. We have a fairly good grasp of what technology can provide.

We are also quite aware of the gap between that affordance and its realisation. What technology does or fails to do in education depends far less on what it can do and far more on what education allows it to do. The gap between the two is accounted for, in part, by such factors as the technological paradox, technocentrism and misguided research (Papert, 1990; Brennan, 2015). These factors prevent the potential of what could happen from being realised.

But should everything that technology can make happen actually take place? Visionaries tell us that more instruction will take place through remote communication. Is this what we really want? How compatible is this change with what we know, for example, about the lonely students' difficulties with self-regulated learning? Do we want to move socialisation from the school-based peer group to the family den?

To use Sarason's (1984) wise words, in education, not everything possible, wondrous as it might be, is necessarily desirable (Sarason, 1984). Clearly, the ability to do something does not make it also desirable only as it is possible. There are many bandwagons to join, but only a handful can be considered educationally desirable. But desirable in light of what? If technology is allowed to transform education, will this transformation be driven by what is technologically possible or by what is desirable? Will technology be a source of new possibilities to be judged in the light of a wider educational rationale, or will the rationale be drawn around the bull's eye of what technology affords? Will technology be allowed to play the role of the great educational seducer, a bandwagon luring education to hop on it and join the e-commerce crowd? Put differently, will the technological tail be allowed to wag the educational dog, or will it be the other way around?

A persuasive, practical educational rationale likely will be based on three foundations. First, we need a vision of the graduate we want our educational system to cultivate. As I see it, in this age of the postmodern reduction of criteria for judgment and decision making, when knowledge multiplies every couple of years, when workers frequently change their vocations, when access to information has become more important than possession and when technology is so dominant, we want graduates to be independent, mindful thinkers, skilled in lifelong learning, capable of intelligently handling complex problems alone and in teams and guided by social values that transcend egotistic benefits.

Second, a good, useful rationale will consider what intelligent learning is. As I, like many others, see it, intelligent learning is a constructive process of guided knowledge building supported by teamwork. Bereiter and Scardamalia (2014) add such ideas as intentionality, as in intentional learning, and Greeno (2012) includes participation. Seen in the light of a rationale based on such a conception of intelligent learning, it is reasonable to wonder, with Lo, Chan and Yeh (2012) and Chen (2008), whether Web-based activities allow genuine construction of knowledge (which they do not) and whether the web's flood of information promotes higher-order thinking.

AND THEN, OF NO LESSER IMPORTANCE, IS AN UNDERSTANDING OF WHAT TECHNOLOGY CAN AFFORD

Rationales which use the knowledge integration framework and constructivist principles—the physical and virtual laboratories developed and realised by De Jong, Linn and Zacharia (2013), MySystem by Svihla and Linn (2012) and web-based inquiry science environment by Zhang and Linn (2013)—are prime examples of a vision determining the role of technology, not the other way around. Education is far too important to society to be wagged by the technological tail. Let technology show us what can be done, and let educational considerations determine what is done in actuality.

NOTE

[1] While this chapter was in its final stages, Salomon passed away. Thomas Arnesen helped with the preparation of this chapter.

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ABOUT THE AUTHOR

Gavriel Salomon was an Israeli educational psychologist who has conducted research cognition and instruction, in particular the cognitive effects of media's symbol systems, transfer of learning, and the design of cognitive tools and technology-afforded learning environments. He was a professor in the department of education at the University of Haifa and at the University College of Stord/Haugesund.

HOWARD GARDNER

9. TRIBUTE TO GAVRIEL SALOMON

Though we grew up in separate countries, and had quite different childhoods, Gabi and I easily connected and became friends many years ago. Sometimes we've joked it is because we were both "Jaeckes"—literally "Jackets"—a phrase used somewhat disparagingly to refer to Jews who are of German rather than of Eastern European or Sephardic background and so always erred on the side of formality, rather than being unbuttoned in dress and in demeanor.

Anyway, whether it was our outside "Jaecke" or something beneath the surface, we shared interests, friends, and even publications for many years. There's a picture of us around 1971, taken from a conference in Toronto at which were gathered a score of scholars (all men, a sign of the times) who were interested in the role of media, symbolic systems, and various kinds of natural and artificial languages in human expression and communication. This interest had penetrated philosophy in earlier decades—for example Charles Sanders Peirce, Susanne Langer, Ernst Cassirer, and my own teacher Nelson Goodman. But by the early 1970s, it was becoming part of the vocabulary and the thinking of psychologists and educators. After all, we were now working in a cognitive era, rather than in the earlier behaviorist era, which explicitly barred any "mentalistic" terms or concepts.

And so, each in our own way, sometimes working with one another, sometimes alone, sometimes with other colleagues, Gabi and I contributed to what came to be called a "symbol system approach." This initiative in the social sciences focused on how individuals—and particularly younger persons—decode and make sense of the myriad of symbolic systems, technologies, and media that human cultures have invented over the ages to make sense of and interpret the world. Gabi was a pioneer in thinking about the affordances of various media of communication, especially television, and the ways in which different cultures related to those media.

I will always be grateful to Gabi for his support of me in a very challenging scholarly environment. For a number of years, at the annual meeting of the American Educational Research Association, I debated with our mutual colleague Elliot Eisner. Eisner always took the position that a work of art—for example, a novel—was appropriate for a doctoral dissertation. I argued, in contrast, that dissertations should be based upon scholarly disciplines: I did not care how good a novel was in literary terms, I cared about whether it was based on appropriate evidence. Those who know the membership of AERA were not surprised that the audience overwhelmingly took Elliot's position. I joked that out of an audience of 1500 persons, 1498 agreed with Elliot. Only one person—Gabi—agreed with me… at least I *think* he did!

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In the last decades of his productive scholarly life, Gabi chose a uniquely important and uniquely challenging issue: "peace studies." It seems fair to infer that, as we reach our later years, we are less interested in understanding for its own sake (however wonderful that is) and more interested in whether we can use our knowledge—old or newly acquired—to try to improve the state of the world. And what bigger and more important issue than trying to nudge the world, and especially the dangerous part of the world in which Gabi had always lived, closer to a State of Peace?

During that twenty year period, Gabi carried out ingenious studies and also gathered a comprehensive, perhaps unique, mastery of the literature. He documented how difficult it is to bring together parties that have long been at odds with one another and also discerned and documented more promising avenues for doing so. On Gabi's analysis, it became clear that, barring a miracle, one-shot exposures could not work; intensive, lengthy, and multi-faceted relations were much more likely to hone and raise the sensitivities of hitherto warring parties. Gabi thought hard about the role of the digital media—changing rapidly—in aiding these processes. We are still in the early stages of pondering this question, and the digital media are changing very rapidly. But once again, Gabi was a pioneer—in raising this question and in suggesting what the possible answers might be.

Gabi's lively mind and energetic personality brought pleasure to the many individuals all over the world who had the privilege of knowing him. I always looked forward to my meetings with Gabi—wherever they took place—and I was always delighted—if sometimes a bit exhausted—after our walks, talks, meals, and joint presentations. I remember fondly his very expressive and emphatic voice and his hearty laugh. The important questions that he raised over the decades—as well as the intriguing answers that he provided—provided stimulation and nourishment for the whole scholarly community and will continue to do so for many years to come.

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Howard Gardner is the John H. and Elisabeth A. Hobbs Professor of Cognition and Education at the Harvard Graduate School of Education. He also holds positions as Adjunct Professor of Psychology at Harvard University and Senior Director of Harvard Project Zero. Among numerous honors, Gardner received a MacArthur Prize Fellowship in 1981 and the University of Louisville's Grawemeyer Award in Education in 1990. He has received honorary degrees from thirty-one colleges and universities. He has twice been selected by Foreign Policy and Prospect magazines as one of the 100 most influential public intellectuals in the world. In 2011, Gardner received the Prince of Asturias Award for Social Sciences, and in 2015, he was awarded the Brock International Prize in Education.

DAVID PERKINS

10. TRIBUTE TO GABI SALOMON

Gavriel Salomon was a friend, colleague, and partner in writing for most of my professional life. We first met when he came to the Harvard Graduate School of Education as a visiting scholar, working with Project Zero, a research group that has been my intellectual home since its founding in 1967. We hit it off and began to collaborate, beginning with a classic and deeply vexing puzzle of education, transfer of learning.

Between 1987 and 1989, we published five articles related to transfer, most notably "Rocky Roads to Transfer" in *Educational Psychologist* and "Are Cognitive Skills Context Bound?" in *Educational Researcher*. Contrary to the trend in the literature then, we argued that learning for transfer, even far transfer, could and did happen … under the right conditions.

We defined two paths for transfer, the *high road*, which involved mindful reflection and connection making, and the *low road*, which involved extensive diverse practice. The predominantly disappointing record findings about transfer at that time, going back to Thorndike at the turn of the century, reflected a reality of most classrooms and laboratory experiments: not much attention to either mindful reflection or extensive diverse practice. Broad transfer from education requires teaching in ways that establish the conditions for it.

In the years that followed, Gabi and I collaborated on several fronts. We continued to write about transfer from time to time. We analyzed different aspects of social learning. We addressed more than once whether digital technologies – and their predecessors, the "technologies" of literacy – make people smarter in a meaningful sense. On that, our answer was yes, and in three different ways: effects "with" (while using), "of" (residual impact when not using) and "through" (long-term impact changing the underlying activity systems by which things get done).

Appropriate to this theme, most of our communication and co-writing occurred by email – effects "with" technology. To be sure, every couple of years, we would find ourselves at the same conference, or Gabi would visit Boston or I would visit Israel for one or another reason, and we would have zesty conversations, only some of them toward written products. But most of the heavy lifting occurred via the light medium of electronic bits and bytes.

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All in all, we published thirteen articles together. The last, like the first, addressed transfer of learning, appearing as "Knowledge to Go," a synthesis article at the end of the special issue on transfer in *Educational Psychologist* in 2012. We revisited the idea of high road and low road transfer, emphasizing a dispositional perspective to explore the emotional and motivational sides of transfer.

In the later years of his professional life, Gabi turned to peace education as a fundamental human problem resonant with the complexities of power, politics, and education in Israel. Early in the process, he said, "Dave, I need your help thinking about this." So I said okay, although nothing could have been further from my mind, began to learn something of the literature, participated in some conferences, wrote a couple of articles, and in fact taught a course on peace education a couple of times at the Harvard Graduate School of Education. We had several probing and generative conversations about the dynamics of peace and war and the challenges of peace education, although in this particular area we never co-authored anything.

All this was especially rewarding work, but even more special was Gabi as a vivid character – energetic, witty, sarcastic, assertive, irrepressible, a well of endless jokes as well as potent insights. As is perhaps the case for many of us about people who have passed along, I have a favorite memory. Many years ago, Gabi invited me to Israel and, as part of our general program of scholarly conversations and poking around, took me to Masada. We did what most tourists would do: took the cable car to the top and walked down the Snake Path.

And it was quite a walk! At the top, Gabi regaled me with the history of Masada, but as we descended, we talked about a seeming impossibility: mindless mindfulness. Mindfulness of one sort or another was a frequent theme for Gabi, and also for me as someone who has worked a fair bit on intelligence and thinking skills. On this occasion we found ourselves exploring the idea that mindfulness need not always be mindful. Mindful moves, like reaching for a counterexample, trying to formulate a argument, or looking at a situation from another's perspective, might ultimately develop into second nature, habits of mind deployed almost reflexively.

By the time we reached the bottom, we had decided to reject the default position that mindful mindfulness was a meaningless oxymoron. We had embraced the paradoxical conceptual space of mindless mindfulness.

Gabi himself was certainly an icon of mindless mindfulness, his critical and creative faculties always reflexively turning in unexpected directions – and for that matter an icon of mindful mindfulness too. Well, Gabi has come down from Masada for the last time. The memory of him helps me to keep mindful of many things, including how precariously we are situated in the years we have.

ABOUT THE AUTHOR

David Perkins is Carl H. Pforzheimer, Jr. Research Professor of Teaching and Learning, Learning and Teaching Program and a founding member of Harvard Project Zero, a basic research project at the Harvard Graduate School of Education investigating human symbolic capacities and their development. For many years, he served as codirector, and is now senior codirector and a member of the steering committee. Perkins conducts research on creativity in the arts and sciences, informal reasoning, problem solving, understanding, individual and organizational learning, and the teaching of thinking skills.

DANIEL BAR-TAL

11. GAVRIEL SALOMON

Between a Researcher and a Peace Activist

Although until early 2000 Gabi Salomon was mostly known in the area of educational psychology as a world expert on cognitive effects of media and technology on learning, few of his colleagues abroad new that he is a very dedicated peace activist who struggled to bring peaceful conflict resolution to the society that has been ridden by a bloody and exhausting conflict. In his first part of the career he achieved a prominent place in the gallery of science. As an educational psychologist he got many different awards for his meaningful contribution that advanced the knowledge in educational psychology.

Then around the 2000 Gabi left the glory of his success and moved to a completely new area—peace education. There, he began a new theoretical thinking and new line of research. I believe that the events in Israel had a determinative effect on this major change. On November 4th, 1995 the Prime Minister Itzhak Rabin who brought the message of peace with the Palestinians to the Israeli society was murdered by a Jew who wished to stop this process. In retrospect he succeeded—with the murder of the Prime Minister the peace process began to die. In 2000, after the unsuccessful ending of the Camp David summit meeting between the Israeli Prime Minister Ehud Barak and the Chairman of the PLO Yasser Arafat, and the beginning of the second Palestinian violent uprising (Al Aqsa Intifada), it has begun to become clear that the peace process is suffering a very serious wound. It was in this period that Gabi began his second journey in the academic career.

One indicator of Gabi's new journey was an organization in May 2000 of a week-long peace education workshop at the University of Haifa with the participation of about 30 scholars from conflict involved countries like Croatia, Rwanda, Cyprus and of course Israel. The outcome of this inspiring workshop was a published coedited book in 2002 "Peace education: The concept, principles, and practices around the world". In this beginning Gabi set in fact the agenda for his research. He diagnosed that the area of peace education is suffering from lack of scientific research. He thought that much of the work about peace education is intuitive, based on limited practical experience, or grounded in idealistic view. The area showed more what is desired than what is in possible. Thus in the introduction of the book is written "*This book is a modest attempt to address these issues and by so doing help to advance the scholarship of the field of peace education*".

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In the early 2000 he founded in the University of Haifa the Center for Research on Peace Education (CERPE) with the goal to advance the field of peace, reconciliation and partnership education through conceptual development and empirical research. This institution provided Gabi with the stage where he could dive into the world of research about peace education. Already in 2005 Gabi drew five lessons from his research:

(1) The kinds of changes desired by peace educators cannot be sustained in the face of continuous adverse violent context in the absence of continued scaffolding and reinforcement of the changes. (2) A direct approach that moves the participants to step into their adversary's shoes and legitimize its perspective may arouse strong resistance as it may threaten participants' sense of righteousness, victimhood, and justness in own goals. But learning about another remote conflict may circumvent that obstacle. (3) Strong negative emotions interfere with the ability to examine and adopt the other side's perspective or show much empathy with it as such experiences often threaten one's sense of identity vis-à-vis that of the adversary. (4) Adversaries come to joint peace education programs with incompatible, even opposing agendas and perceptions that need to be taken into consideration. It may well be the case that working through these differences, using group processes, can establish some common ground. (5) In turn, the establishment of common ground may lead to unanticipated and serendipitous worthwhile goals such as a deeper understanding of one's self and that of the other side.

On the basis of this understanding Gabi formulated four major challenges for peace education in regions of intractable conflict: (a) The creation of a "ripple effect" whereby the impact of peace education programs spreads to wider into social circles of society; (b) increasing the endurance of desired program effects in the face of their easy erosion; (c) the need for differential programs, given the differences in culture and in the role that each adversary plays in the conflict; and (d) the need to find ways to bridge between general dispositions, principles and values and their application in specific situations where competing motivations are dominant. It is argued that the four major challenges are common also to other kinds of programs: Human rights, anti-racism, tolerance and such as many are carried out in socio-political contexts that negate the messages of the programs.

The climax of this line of research was the co-edited volume of the Handbook on Peace Education with Edward Cairns in 2010. In the introduction they wrote that the book is needed because of two major reasons: (1) Peace is an important value and the world has to understand what can bring it. (2) There is needed to show that peace education is a wide and complex concept. The twenty two chapters of the book provide the most comprehensive and influential contribution to the study of peace education. As far as I know this is the seminal book in this area.

But Gabi was not only a researcher closed in the ivory tower. He was also a practitioner who brought his knowledge into the field. In August 2008, Prof. Yuli Tamir, then Israel's Minister of Education, appointed a public committee to define the state policy in the field of education for a shared life for Arabs and Jews. The

committee was appointed in the wake of data indicating a growing level of alienation and animosity between the Jewish and Arab populations, as well as mutual fear, de-legitimization and mistrust. Prof Gavriel Salomon and Dr Muhammed Essawi were appointed to serve as co-chairs of the committee. The committee recommended the following policy: (1) The Ministry of Education is in charge of promoting education toward a shared life in collaboration with local governments, the civil society and business sectors, and other government ministries. (2) Education toward a shared Jewish-Arab life should be anchored as an obligatory topic in one subject matter area (civics). There should be additional components that can be chosen by each school as it sees fit. (3) Education toward a shared life should be imparted continuously, from kindergarten to 12th grade. (4) Education toward a shared life should take place in three circles: knowledge; school culture; and individual and group experiences. (5) Education toward a shared life should be grounded in school subjects: Homeland, social studies and civics in elementary school, and civics in junior and senior high school. Furthermore, education toward a shared life should be integrated into other relevant school subjects, especially history, literature, geography, and sociology. (6) Education toward a shared life studies should have a required core embedded in the above subjects, and elective activities conducted at the discretion of each school. (7) Encounters between Jews and Arabs, whether face-to-face or virtual encounters through other media, constitute an essential component in education toward a shared life, provided that such encounters are sustained over time and under professional supervision. (8) For Jews, education toward a shared life should include Arab culture and language studies. (9) The Ministry of Education should assume responsibility for training teachers, principals, and other educators in this field. The Ministry should promote the integration of Arab teachers in Jewish schools, and of Jewish teachers in Arab schools, and should initiate the establishment of joint Arab-Jewish schools. The Ministry should take steps to develop rich age-and sector-appropriate learning materials that are accessible online and at local Teacher's centers. (10) Implementation of education toward a shared life should be accompanied by periodic monitoring. The report was elaborated and specified various steps that have to be taken. But new elections took place and the next Minister of Education Gideon Saar who was nationalistically oriented, rejected the report.

Finally Gabi was also a peace activist. This means that he was a vocal opponent of demonstration of racist and nationalistic practices that have been appearing in the public space, including in the educational system. We could hear his voice in the radio or see him the television criticizing racism and nationalistic tendencies in education and demanding an expansion of education for democracy. He was a consistent and stable activist of struggle against growing racism in Israel. He participated in every move that was taken in Israel to fight racism in the last 10 years. With his immense energy and determination he led many of these moves. Exactly the same can be said about his struggle for peace. He was a tireless fighter that could be seen in every activity—demonstration, petition, or other acts. In September 2015 he gave his last public speech in Tel Aviv, protesting incidents of racism, arriving on the

wheel chair and with the oxygen tank. In the last months he was writing blogs about the moral deterioration of Israel. In his last activity he was recruiting prominent Jews, convincing them to support a movement of Save Israel – Stop the Occupation (SISO) of which he was an integral part.

I deeply believe that few people change the world. Gabi Salomon belonged to this category of individuals. He was charismatic with an ability to lead people. He was determined and motivated – led by his moral and humanistic values. His wisdom and intelligence allowed him to conceptualize goals and their rationales. He was a born leader for those in Israel who saw the tide of racism and nationalism with xenophobia and righteousness taking over the consciousness of the leaders and the majority of Jewish society members. His death is a loss for those who have the hope of changing the way Israel is moving.

REFERENCE

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