Concept-guided development of classroom use of ICT

Concept-specific types of ICT use and their integration into teachers’ practices

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Concept-guided development of classroom use of ICT: developing classroom use of ICT with a strong link to the school’s educational concept

Does a concept-guided approach in schools with either a ‘traditional’ or an ‘innovative’ educational concept contribute to the development of ICT use that becomes integrated in the teachers’ classroom practices?

In order to answer this question we performed four, mainly qualitative, studies in five primary schools: two ‘traditional’ and three ‘innovative’ schools that participated in a two-year ICT innovation project.

These studies showed that concept-guided development of ICT use can lead to distinguishable types of ICT use in schools with different educational concepts. The developed ICT use became integrated into the teachers’ practices, although this integration was not necessarily sustainable.

We conclude that it is a promising approach that can help schools realise the potential of classroom technology, but that concept-specific differences need to be taken into account.

Uitnodiging

voor het bijwonen van de openbare verdediging van het proefschrift

Concept-guided development of classroom use of ICT: Concept-specific types of ICT use and their integration into teachers’ practices

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Concept-guided development of classroom use of ICT: concept-specific types of ICT use and their integration into teachers’ practices

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Concept-guided development of classroom use of ICT: concept-specific types of ICT use and their integration into teachers’ practices

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op gezag van de Rector Magnificus

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ten overstaan van een door het College voor Promoties ingestelde commissie,

in het openbaar te verdedigen in de Agnietenkapel

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The field of educational technology research continues to struggle with the shifting landscape of technology integration in teaching and learning. […] Yet, the interplay and complexity of technology integration continues to be elusive.

Howard & Thomson, 2015, p. 3

Technology can amplify great teaching but great technology cannot replace poor teaching.

OECD 2015
Chapter 1       General introduction

This thesis presents four studies exploring whether concept-guided development of ICT use in education is a promising approach to integrate technology into teachers’ practices in a meaningful way. This technology use can entail anything from practicing skills or web searching with the use of (desktop, laptop or handheld) computers to watching videos on an interactive whiteboard or learning in a virtual reality setting, playing simulation games et cetera. While the possibilities for using technology to support and enhance learning and teaching are increasing fast and great investments are made by governments and schools to take full advantage of these possibilities, the adoption and integration of technologies lag behind the aspirations. This has been the subject of many studies over the past three decades, leading to different types of suggestions for a solution. One approach that has been proposed is the concept-guided development of technology use by schools, an approach in which the school’s educational concept functions as the main starting point for the development of the school’s technology use. In this thesis four studies are presented in which we explored how this approach was carried out in a project in which five primary schools in the Netherlands with different educational concepts participated and the resulting technology use in the participating schools.

Conceptual framework

Digital technology in the classroom

Educational technology has been a major focus of interest of educators, school leaders and researchers over the past thirty years. It is also referred to as classroom technology, information and communication technology (ICT) in education or ICT for education
Technology can be roughly divided into technology used in schools to support teaching and learning or to support the school’s administrative processes. This dissertation focuses solely on the former.

Since the introduction of the first personal computers in the classroom in the 1980’s – e.g. the ACOT project (Dwyer, Ringstaff, & Sandholtz, 1991) or the 100-schools project in the Netherlands (Voogt & Ten Brummelhuis, 2014) – schools today can choose from an abundance of tools with applications for myriad educational purposes. These tools include both hardware, like desktop, laptop and handheld computers, digital cameras and interactive whiteboards, and software, like educational and off-the-shelf software programs, virtual reality, information from the internet, and communication and collaboration tools (Web 2.0).

Rationales for ICT-supported teaching and learning

In the literature a number of reasons can be found for using or promoting the use of educational technologies. One rationale behind the promotion and adoption of technology in classroom practices is the omnipresence of digital information and communication technologies in our everyday lives today. According to a recent study from Pew Research Center nearly 75 per cent of teens aged 13 to 17 in the United States have or have access to a smartphone. 91 per cent of teens go online from mobile devices at least occasionally and of these teens 94 per cent go online daily or more often (Lenhart, 2015). Research in the Netherlands shows even higher rates. Here 99 per cent of teens aged 13 to 18 has a mobile phone, 98 per cent of these are smartphones. Laptops and tablets are used daily by about 35 per cent and a couple of times a week by about 30 per cent (Kennisnet, 2015). The fact that technology has become such a self-evident part of young people’s lives leads some to argue that it would be an anachronism not to include a similar level of ‘technofication’ in the school place (Hammond, 2014).

Closely linked to this is the argument that to be able to function in such a computerised, digitalised information or knowledge society, one needs digital and information skills and schools should take an active role in helping students develop these skills. Both at
work and in our private lives we need to be able to handle digital devices and to handle and process the continuous streams of information that reach us constantly and from all directions (Anderson, 2008; Voogt & Roblin, 2010). Despite the fact that children today grow up with digital technology as a self-evident part of life, it has already become clear that these ‘digital natives’ do not automatically develop digital skills automatically (Bennett, Maton, & Kervin, 2008). In addition to these technology-related skills also the development of other ‘21st century skills’ such as collaboration and self-regulated learning are believed to be supported and promoted by the use of learning technologies (Aesaert, Vanderlinde, Tondeur, & van Braak, 2013; Dede, 2010; Lemke, Coughlin, & Reifschneider, 2009; Voogt & Pelgrum, 2005; Voogt & Roblin, 2012).

A third rationale behind the promotion of educational technology derives from its – not undisputed – potential to improve learning processes, by making teaching and learning either more efficient, more motivating and/or better fit for the ways in which today’s students tend to learn. Technology can help teachers to deal with diversity among students (e.g. Heemskerk, Volman, ten Dam & Admiraal, 2011) and to make lessons more interactive (Smith, Higgins, Wall, & Miller, 2005; Kennewell, Tanner, Jones, & Beauchamp, 2008). The use of technology in the classroom has been found to lead to more engaging learning activities (Bransford, Brown, & Cocking, 2003; Deany, Ruthven, & Hennessy, 2005; Balanskat, Blamire, & Kefala, 2006) and to more effective education with better learning results (cf. Archer, Savage, Sanghera-Sidhu, Wood, Gottardo, & Chen, 2014; Cheung & Slavin, 2012; Cheung & Slavin, 2013; Kulik 2003; Lemke, Coughlin, & Reifschneider, 2009; Li & Ma 2010; Webb & Cox, 2004). There are also studies, however, that have shown no such effects or even the contrary. An OECD study recently suggested that moderate use of computers at school may lead to ‘somewhat better learning outcomes’ than rare use of computers, while very frequent use is associated with much lower learning outcomes (OECD, 2015). Despite this ambiguity in the literature the (alleged) power of technology to enhance learning processes and outcomes continues to be a persuasive rationale behind the promotion of its use in the classroom.
Challenges to the integration of technology use in the classroom

From each of these perspectives – the omnipresence of ICT, the need for digital and other 21st century skills, and the improvement of learning processes – the promise of classroom technology is high and for decades now both policy makers, school leaders and teachers have made efforts to fulfil this promise. Considerable investments have been made to promote and facilitate technology use, but nevertheless the actual integration of technology use in most schools still does not live up to the expectations (Lemke et al., 2009; OECD, 2015). In general the integration of classroom technology use means that the technology use becomes an integral part of how the classroom functions, i.e. that it becomes as accessible as all other classroom tools (ISTE, 2002), or, in other words, that it becomes a natural element in classroom practice (Vanderlinde & van Braak, 2010). Integration can be described at the level of the individual teacher (i.e. integration into teachers’ practices), at the level of the school (i.e. integration into the school organisation and curriculum) or at the national level (i.e. integration into the national curriculum). Several factors have been identified that either promote or hinder the actual implementation and integration of technology use into teachers’ practices. One of the factors at the level of the teacher are teachers’ ICT-related competencies. These include knowledge, training, teachers’ readiness for ICT integration, and their beliefs, ICT attitude, and ICT skills (Ertmer, 2005; Hew & Brush, 2007; Inan & Lowther, 2010; Pelgrum, 2001; Tondeur, Hermans, van Braak, & Valcke, 2008; Van Braak, Tondeur & Valcke, 2004; Ward & Parr, 2010). Factors at the school level include issues of ICT infrastructure, time, and provision of training and support (Hew & Brush, 2007; Inan & Lowther, 2010; Pelgrum, 2001; van Braak et al., 2004; Ward & Parr, 2010), ICT coordination and school-wide ICT integration planning (Hew & Brush, 2007; Vanderlinde, van Braak, & Hermans, 2009). The integration into the teacher’s practice and into the school organisation and curriculum have been shown to be interdependent. While a digital school infrastructure is obviously necessary for teachers to integrate ICT into their classroom practices, it is not sufficient; even when the necessary tools are available in the classroom teachers do not necessarily use them (Inan & Lowther, 2010). A condition that concerns both the teacher level and the school level
is the educational concept of the school. The term ‘concept’ in this context refers to the educational views (values, beliefs, perspectives) on which a school’s classroom practices are based. Research suggests that a good fit between the educational concept of the school and the ICT use that is aimed at is another important condition for the successful integration of ICT into educational practices. Zhao, Pugh, Sheldon and Byers (2002) describe this in terms of the distance between the ICT innovation (i.e. the intended ICT use of the school) on the one hand, and the school’s educational culture and practice on the other hand. A short distance between the innovation and the school’s culture and practice promotes successful ICT integration. Similarly, Tolmie (2001) finds that how and with what learning effects ICT resources are used, depends on how well they fit in with the established patterns of activity. According to Niederhauser and Stoddart (2001) teachers are inclined to apply technology in a manner that is consistent with their personal perspectives about curriculum and instructional practice. Such findings have led to a shift in the literature from a focus on the technology and its opportunities for teaching and learning to a focus on pedagogical aspirations and the ways in which certain technologies can support these (Ertmer & Ottenbreit-Leftwich, 2013; Kampylis et al., 2013; Kirkwood & Price, 2005; Lewin & McNichol, 2015; Mor & Mogilevsky, 2013; Ten Brummelhuis & Kuiper, 2008).

Sustainable integration of technology use

In order for innovations in education to lead to the intended effects they need to be sustained over a longer period of time (Jerald, 2005). In other words, newly developed technology use needs to be integrated and this integration also needs to be sustainable. One aspect of sustainability of an innovation that has received attention in the literature on educational innovations is longevity, i.e. the extent to which an innovation lasts over time (Datnow, 2005). According to Jerald (2005) an innovation, in order to be sustainable, also needs to be extended to ‘next generation improvements’ and, over time, to be adapted to the school’s changing needs and possibilities.

Based on the literature on integration and sustainable integration of technology use we propose that the sustained integration of technology use (in general and/or of one
specific use of technology) that supports learning is the ultimate goal of development of technology use.

Concept-guided development of technology use

Consistent with the arguments for promoting a favorable fit between the educational concept of a school and its technology use, this study proposes a concept-guided approach to developing technology use. The term educational concept in this respect encompasses both the school’s pedagogical practices and the beliefs and perspectives that motivate these practices. Central to the concept-guided approach is that the school’s educational concept functions as the main starting point for developing its technology use. Classroom technology is often used explicitly as a lever to transform teaching and learning into constructivist classroom practices (Ertmer, 2005; Vanderlinde & van Braak, 2010), yet studies have shown that teachers tend to use technology in ways that fit their pedagogical approach (Niederhauser & Stoddart, 2001; Tolmie, 2001; Zhao et al., 2002). The concept-guided approach aims to use this mechanism in order to develop technology use that can support classroom practices without necessarily transforming them.

This is especially relevant in countries with a decentralised educational system like in the Netherlands, with only a general national curriculum and a considerable amount of freedom for schools to decide how to realise this curriculum. A concept-guided approach can contribute to developing technology use that fits the variety of educational concepts in such a system. By focusing first on what is pedagogically desirable (i.e. what type of teaching and learning is aimed at) in a particular school, before investigating what technology might promote this, the developed technology can be expected to reflect the school’s educational concept and to be more successfully integrated. There have not been any studies so far that have investigated to what types of technology use this approach can lead in schools with different educational concepts and to what extent such a concept-guided approach to technology development would lead to lasting, i.e. sustainably integrated technology use.
Context of this study

The four studies presented in this thesis were performed in the context of a project\(^1\) in which five primary schools in the Netherlands developed technology-enhanced learning arrangements in a concept-guided way. The learning arrangements were realised in the course of two school years. The literature shows that ICT can support a variety of educational concepts (Niederhauser & Stoddart, 2001; Inan et al., 2010; Higgins & Spitulnik, 2008). Both individual and collaborative and both learner-directed or teacher-directed learning can be supported by ICT (Ten Brummelhuis & Kuiper 2008) and ICT can facilitate the individualisation of learning processes as well as support learning within a learning community (Volman, 2005). In order to explore the impact of a concept-guided approach to the development of ICT use in a variety of school types the schools participating in this project were selected based on their educational concept. Two schools had an educational concept that was labeled as ‘traditional’, which refers to a fixed curriculum and a strongly teacher-directed approach. Three schools were labeled as ‘innovative’, indicating a more open curriculum and a student-centred approach. All schools were already using ICT to support teaching and learning, yet were aiming at more intensive and/or more effective ICT use. The schools are described in more detail in the following chapters. Table 1.1 shows an overview of the participating schools and the grades that were involved in the learning arrangements. The first two schools are the schools that were labelled as ‘traditional’, the other three schools as ‘innovative’.

<table>
<thead>
<tr>
<th>School name</th>
<th>Grades involved in learning arrangements 1 to 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Princess Amalia</td>
<td>5/6, 3, 6, 3</td>
</tr>
<tr>
<td>Alma Mater</td>
<td>1/2, 2, 6, K (age 4-5 yrs)</td>
</tr>
</tbody>
</table>

\(^1\) This was called the Cumulus project, initiated by educational consultancy company APS and financed by the Dutch public organisation for education & ICT Kennisnet and APS. VU University Amsterdam and HAN University of Applied Sciences supplied the research staff.
<table>
<thead>
<tr>
<th>School</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Beehive</td>
<td>2/3/4</td>
<td>5/6</td>
<td>3/4 + 5/6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Queen Beatrix</td>
<td>4/5/6</td>
<td>4/5/6</td>
<td>4/5/6</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2 classes)</td>
<td>(2 classes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beech Grove</td>
<td>2/3/4</td>
<td>2/3/4</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4 classes)</td>
<td>(2 classes)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: all the learning arrangements were studied in one class (with one teacher and one or more grades), unless stated otherwise.

In the course of two school years a team of teachers at each school was involved in the project. The teams included two to eight teachers at a time and the teachers participated on a voluntary basis. Each team was supported in designing and implementing up to four technology-supported learning arrangements of their own choosing. A learning arrangement would consist of a lesson plan, including learning goals, tools and activities, and could concern any school subject. The technology use in a learning arrangement could entail anything from the use of ‘drill-and-practice’ software to the use of a wide range of technological tools to support a variety of learning activities in an enquiry-based project. The teachers were coached by educational consultants from the educational consultancy organisation that participated in the project (see note 1). At the start of the project consultants with expertise concerning processes of educational innovation helped the teachers reflect on their school’s educational concept and their school’s ambitions for intensifying its use of technology in line with this concept. Based on this reflection the learning arrangements were designed as the teachers saw best fit. They were supported in choosing technology for these arrangements by advisors with expertise in the field of educational technology. The teacher-as-designer approach was expected to favourably affect the implementation and integration of the designed learning arrangements by installing a sense of ownership in the teachers (Handelzalts, 2009; Ketelaar, Beijaard, den Brok, & Boshuizen, 2013; Maher, 1987). No specific limitations were set with regard to the ICT tools that were to be used, the duration of the learning arrangement or the type or frequency of ICT-supported activities. The schools were supplied with the necessary ICT tools. At three moments during the project all participants – i.e. teachers, school leaders, consultants and researchers – gathered to
discuss the proceeding of the project. Plans and experiences were exchanged and preliminary research findings were presented and discussed.

**General research problem and questions**

The four studies presented in this thesis all have an explorative character as the proposed concept-guided approach to technology integration was new and no previous studies of this type of technology development and integration had been performed so far. The overarching purpose of these studies was to investigate whether concept-guided development of ICT use in education is indeed a promising approach, by exploring how this approach was carried out in the project with five primary schools and the integration of the resulting technology use in the participating schools. All studies focused on the level of the participating teachers and their classrooms. The overarching research question was:

*To what extent does a concept-guided approach in schools with either a ‘traditional’ or an ‘innovative’ educational concept contribute to the development of ICT use that becomes integrated into the teachers’ classroom practices?*

In order to answer this question we focused on four sub questions. The first two questions concern the technology use that resulted from the concept-guided approach in the participating schools, both comprehensively (question 1) and more specifically, focusing on the use of the interactive whiteboard (IWB) (question 2). The next two questions focus on the integration of the developed technology use in the teachers’ classroom practices (question 3) and its sustainability after the project ended (question 4). The questions were formulated as follows:

1. *To what extent does concept-guided development of ICT-enhanced learning arrangements in primary schools lead to distinguishable types of ICT use?*
2. *What types of classroom interactivity does the interactive whiteboard support in ‘traditional’ and ‘innovative’ schools that develop their ICT use in a concept-guided way?*
3. How can the achieved integration of technology in ‘traditional’ and ‘innovative’ schools that develop their use of technology in a concept-guided way be characterised in quantitative and qualitative terms?

4. a. Which technology use that was developed during the project was sustained, i.e. was still visible in the school one year after the project had ended?
   b. Was the technology use developed further during the year after the project, and if so: how?

**Methodology**

*Studies 1 and 2: exploring the types of ICT use*

The first two studies focused on describing the technology use that resulted from the concept-guided approach in the participating schools. A total amount of 17 learning arrangements were realised across the five schools over the course of the project. In order to answer the research questions of studies 1 and 2 we analysed extensive data about these learning arrangements, that were gathered in the context of a practice-based research in which teachers and researchers cooperated. For each learning arrangement the teachers formulated their aims and expectations with regard to the learning arrangement, in the form of ‘working hypotheses’, e.g. ‘Interactive spelling lessons with the interactive whiteboard make the lessons more motivating and increase learning results’. Based on these working hypotheses two or more research questions were formulated by the researchers for each learning arrangement, in cooperation with the involved teachers. In addition to these research questions that mostly focused on learning motivation and results, for each learning arrangement a research question was formulated that focused on how the technology was used in the learning arrangements. The main sources of data in most learning arrangements consisted of lesson observations and teacher interviews. The other research instruments that were used included pupil interviews, learner reports, teacher diaries, pupil diaries, and other documents, like teachers’ planning documents or software manuals, depending on the nature of the working hypotheses and subsequent research questions. Based on these
data a report was written by the researchers and member checking with the teams of
teachers involved was used to verify – and if necessary correct – the initial analyses
(Lincoln & Guba, 1985).
The first study presented here focused on the types of ICT use that were developed at
the participating schools. In this study each school represented one case while the
learning arrangements were studied as embedded sub cases (Yin, 2009). The main data
for this study were the reports and some of the raw data of the practice-based research
described above. The reports were subjected to content analysis (Huberman & Miles
1994) and finally a cross-case analysis per school type enabled us to find patterns in the
ICT use related to the school types, in terms of the ICT tools that were available and
used in each learning arrangement, the goals with which these tools were used and the
activities that were performed with these tools.
In the second study, which focused on classroom interactivity with the IWB, video
observations that were part of the data collection of the practice-based research were
used. Observations of six lessons in six different classes at four of the participating
schools were analysed. The interaction with the board was described in terms of teacher
or student-led control of the operation of the board and of the content on the board. The
dialogue that occurred while using the board was described in terms of the teaching and
learning model apparent in the dialogue, i.e. either focusing on knowledge transmission
or knowledge construction. In a cross-case analysis these descriptions were compared in
order to find possible patterns of interactivity per school type (Miles & Huberman,
1994).

Studies 3 and 4: integration of developed ICT use

In our next two studies our focus shifted to the integration and sustainability of the
developed technology use. For these studies the main source of data were semi-
structured focus group interviews that were held at regular intervals with teachers at all
five schools during the project and at two schools one year after the project had ended.
The interviews followed the same interview protocol at each school. The interview
protocol was not directly connected to the working hypotheses concerning the learning
arrangements, instead focusing on more general topics. These topics concerned the teachers’ participation in the project (e.g. ‘what are your experiences with the project so far?’), the technology that was used, and the role it played in the school’s classroom practice, (e.g. ‘to what extent are teaching and learning supported by technology in your school?’). The focus groups at each school consisted of two to eight teachers who participated in the development and/or the realisation of one or more learning arrangements. At all schools at least two to four interviews were held, at the beginning and end of the first year of the project, at the end of the project (end of year 2) and at two schools a fourth interview was held a year after the project had ended. For the third study, which focused on the achieved integration of the developed technology in quantitative and qualitative terms, the quantitative character of the achieved technology integration was captured through summarizing the number or different tools that were used in the learning arrangements and how many computers were available per class. This was based on the reports of all 17 learning arrangements described earlier. The qualitative character of the achieved technology integration was captured by analysing the focus group interviews with regard to how the teachers themselves perceived and valued the developed technology use in their schools. For the fourth study the third and fourth focus group interviews were analysed from the two schools that were visited one last time a year after the project had ended. The teachers’ accounts in the focus group interviews were checked against the descriptions of the learning arrangements at these two schools in the reports. The focus group interviews were transcribed and subjected to content analysis (Huberman & Miles, 1994). A comparison was made between the schools with regard to the found sustainability and grounded theory (Glaser & Strauss, 1999) was used to explore possible explanations of the differences that were found.

Together these four multiple case studies give us a comprehensive and informative overview of different aspects of the technology use that was developed in a concept-guided way by the participating schools. An overview which adds to the existing literature on educational technology and which also has practical implications, both for teachers aiming at improving teaching and learning with technology and policy makers
who need to create the necessary conditions. These implications are discussed at the end of each of the following chapters and in the final chapter.

**Dissertation outline**

The four studies that are reported in this thesis are clustered into two parts. The studies in Part I focus on the technology use that was found in the learning arrangements that the schools developed, answering the questions: does it lead to distinguishable types of technology use? (first study, chapter 2) and does the IWB support different types of interactivity in schools with different educational concepts? (second study, chapter 3). The studies in Part II focus on the integration of this technology use into the schools’ classroom practices, answering the questions: how can the integration achieved by the end of the project be characterised? (third study, chapter 4) and what technology use is sustained after the project and is it developed further? (fourth study, chapter 5). In chapter 6, Conclusion and Discussion, the findings from these four studies are summarised and discussed in order to answer the overarching question. Both practical and theoretical implications of these findings are discussed and suggestions for further research are given.
Part I  Types of ICT use that were developed
Chapter 2  Concept-guided development of ICT use in ‘traditional’ and ‘innovative’ primary schools: what types of ICT use do schools develop?²

Introduction

ICT is by many believed to be capable of making a significant, if not indispensable, contribution to education. Among other things the integration of ICT into school practice is expected – and in some studies also found – to lead to more engaging learning activities (Bransford, Brown, & Cocking, 2003; Deany, Ruthven, & Hennessy, 2005; Balanskat, Blamire, & Kefala, 2006) and to more effective education (Kulik, 2003; Webb & Cox, 2004; Li & Ma, 2010). However, in order to be effective ICT needs to be successfully integrated into classroom practice. Researchers find that many ICT innovation projects fail to establish the fully integrated use of ICT which these projects are aimed at, and therefore also fail to realise the expected effects on learning (Smeets, 2005; Ten Brummelhuis, 2006; Voogt, 2008). Most authors find explaining factors for this problematic integration on the level of the school and/or the teacher (e.g. Hew & Brush, 2007; Ertmer, 2005; Tondeur, Cooper, & Newhouse, 2010; Tondeur, van Braak, & Valcke, 2010; Voogt, Almekinders, van den Akker, & Moonen, 2005; Inan & Lowther, 2010). A range of school and teacher characteristics are mentioned as factors in technology integration, from school ICT policy and school leaders to teachers’ knowledge of and attitudes towards technology.

Another type of factor influencing the integration of teaching and learning technology is found in the distance between the ICT innovation on the one hand and the school’s culture and the innovator’s (i.e. teacher’s) current practice on the other hand; the shorter

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this distance is, the better chances for successful ICT integration are (Zhao, Pugh, Sheldon, & Byers, 2002). This is consistent with findings indicating that how and with what learning effects ICT resources are used depends on how well they fit in with the established patterns of activity, as ICT resources are always introduced into a pre-existing framework of educational and social activity (Tolmie, 2001). Similarly Niederhauser and Stoddart (2001) find that teachers are inclined to apply technology in a manner that is consistent with their personal perspectives about curriculum and instructional practice. In other words, innovations concerning ICT have a higher chance of succeeding if they start from educational ‘desirabilities’ (Salomon & Perkins, 1996) rather than from technological possibilities and novelties (‘technological push’, Ten Brummelhuis & Kuiper, 2008). In this line of reasoning types of ICT use that fit or stay close to the school’s educational concept may be more likely to be effective in terms of their contribution to pupils’ learning processes and outcomes (Kulik, 2003; Webb & Cox, 2004; Ten Brummelhuis, 2006).

These findings suggest that one of the keys to the successful integration of ICT into educational practices lies in ensuring a good fit between the ICT innovation and the educational concepts underpinning these practices. In other words: the apparent relationship between a school’s educational concept and the way ICT is used in its classrooms should be considered when aiming at developing meaningful, effective use of ICT. Research has shown that ICT in general can support a variety of educational concepts (Niederhauser & Stoddart, 2001; Inan, Lowther, Ross, & Strahl, 2010; Higgins & Spitulnik, 2008). ICT-supported learning can for instance be either individual or collaborative and either learner-directed or teacher-directed (Ten Brummelhuis & Kuiper, 2008) and can facilitate the individualisation of learning processes as well as support learning within a learning community (Volman, 2005). So both educational practices with a traditional and an innovative educational concept can be supported by educational technology. The same versatility can be found at the level of particular ICT applications as well. Recent studies on the use of games, for instance, show that games can lead to pupils being more motivated and involved, both in schools where pupils
develop knowledge in an active and exploratory way and in schools which focus on knowledge transmission (Sandford, Ulicsak, Facer, & Rudd, 2007).

To our knowledge no attempts have been made so far to describe what types of ICT use result when the ICT use is developed in a concept-guided way, i.e. so that it fits the educational concept underpinning the practice that is to be supported. Therefore, in this study we characterise the types of ICT use resulting from such a concept-guided approach to ICT innovation. This article presents a descriptive multiple-case study of a project of concept-guided development of ICT. In this project teachers at five schools, with support from experienced advisors, designed and implemented ICT-rich learning arrangements in line with their school’s educational concept. We explore what types of ICT use this approach leads to. The main research question of this study is:

*To what extent does concept-guided development of ICT-enhanced learning arrangements in primary schools lead to distinguishable types of ICT use?*

In order to answer this question we first need to explore how the different uses of ICT that result from concept-guided development of ICT use can be characterised.

**Method**

**Participants and setting**

Five primary schools, across the Netherlands, were selected to participate in the project that formed the context of this study. The schools were selected from the database of the organisation that supported the schools in designing and integrating ICT-enhanced learning arrangements during this project. Schools in this database typically have a relatively high level of ICT use. Participating schools had to be willing and able to invest a considerable amount of time in the project as the teachers would be actively involved in the process of further enhancing the school’s use of ICT.

Two distinguishable types of schools were selected for this project, based on differences in educational concept. The schools were labelled as either ‘traditional’ or ‘innovative’.
The traditional label refers to a fixed curriculum in which standard teaching and learning materials are used, and learning content and activities are directed by the teacher and the materials. ‘Innovative’ indicates a more open curriculum with a focus on self-regulated learning in which pupils have more input in learning content and activities, and teachers often take on a role as coach.

The two ‘traditional’ schools and three ‘innovative’ schools that participated in this project were studied. At each school one or more classes participated. Classes in Dutch primary schools can be homogeneous (one grade per class) or heterogeneous (multi-aged; two or more grade levels per class). The classes involved in the study consisted of 12 to 28 pupils. It was up to the schools to decide which classes would participate in the project.

**Procedure**

In the course of two school years (2007-2008 and 2008-2009) each school was followed closely in the process of designing and realizing four ICT-enhanced learning arrangements that were to be integrated into their educational practice. A total of seventeen learning arrangements was realised in the course of the project. An overview of the participating schools and the learning arrangements that were developed is shown in Table 1.

**Table 1. Overview of participating schools and classes.**

<table>
<thead>
<tr>
<th>School name</th>
<th>Grades involved in learning arrangements 1 to 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Princess Amalia</td>
<td>5/6</td>
</tr>
<tr>
<td>Alma Mater</td>
<td>1/2</td>
</tr>
<tr>
<td>The Beehive</td>
<td>2/3/4</td>
</tr>
<tr>
<td>Queen Beatrix</td>
<td>4/5/6</td>
</tr>
<tr>
<td>(2 classes)</td>
<td>(2 classes)</td>
</tr>
<tr>
<td>Beech Grove</td>
<td>2/3/4</td>
</tr>
<tr>
<td>(4 classes)</td>
<td>(2 classes)</td>
</tr>
</tbody>
</table>
The schools developed these learning arrangements in a ‘concept-guided’ way. A team of teachers at each school was supported in designing and implementing learning arrangements in line with their school’s educational concept (teacher-as-designer; e.g. Maher, 1987). Teachers were supported during the project by educational advisors specialised in guiding innovation projects. During the design phase these advisors helped the teachers reflect on their school’s educational concept and its ambitions for intensifying its use of ICT in line with this concept. This way we expected the schools’ educational concept to be reflected in the resulting learning arrangements. The teacher-as-designer approach was expected to install a sense of ownership in the teachers, which would favourably affect the implementation of the designed learning arrangements (Handelzalts, 2009).

The teachers designed up to four ICT-enhanced learning arrangements and explored which ICT tools – both hardware and software – could support these arrangements in line with their school’s ambitions. A learning arrangement would consist of a lesson plan, materials, and goals, and could concern any school subject. For instance, a learning arrangement could be: the use of an interactive whiteboard to show pictures from the internet as visual enhancement of mathematics instruction, aimed at increasing pupils’ learning motivation. No specific limitations were set with regard to the ICT tools that were to be used, the duration of the learning arrangement or the type or frequency of ICT-supported activities. The schools were supplied with the necessary ICT tools.

**Instruments and data collection**

In this descriptive multiple-case study (Stake, 1994; Yin, 2008), each school represented one case, while the learning arrangements were studied as sub cases. A wide range of qualitative methods of data collection was used to provide rich data for descriptions of each learning arrangement.
During the design phase of each learning arrangement the researchers asked the teachers involved to explicitly state their intentions and expectations with regard to the learning arrangement and the ICT tools that were used in it. These so called ‘working hypotheses’ were used as a source of data. During the implementation phase the main sources of data in most learning arrangements consisted of lesson observations and teacher interviews. The other research instruments that were used included pupil interviews, learner reports, teacher diaries, pupil diaries, and document analysis (e.g. of teachers’ planning documents or software manuals). Because of the great variety of learning arrangements, the research instruments that were used and the frequency with which they were used varied from sub case to sub case, depending on the specific nature of the arrangement (e.g. number of classes involved, pupils’ age, duration of the arrangement, individual or group activities, stationary or mobile activities).

In order to analyse the extent to which distinguishable types of ICT use were developed, the ICT use was operationalised in terms of:

a. ICT tools available to and used by teachers and/or pupils
b. Goals with which these tools were (meant to be) used
c. Activities performed with these tools (by whom and how the tools were used)

The descriptions with regard to the ICT tools that were available and/or used and the activities in which they were used were based on teacher interviews and lesson observations; in some cases this information was also derived from pupil interviews, pupil and teacher diaries and/or documents like a manual for the software that was used in the learning arrangement.

The goals with which the ICT tools were meant to be used were deduced from the teachers’ intentions and expectations explicated in the working hypotheses during the design phase. Teacher interviews during the implementation of each learning arrangement allowed us to gain more insight into the goals as initially formulated by the teachers.

Two teams of researchers collected the data. One team investigated two schools, the other team investigated three schools. Both teams reported to each other regularly on
decisions relating to each sub case study, thus clarifying the procedure they followed. This enabled us to audit the research procedures of the separate (sub) case studies (Halpern, 1983).

Data analysis

The data of each sub case study were first processed and interpreted by the research team investigating the sub case. The various types of data collected were used for triangulation to establish a rich and comprehensive description of the different learning arrangements and the use of ICT within the arrangements. Member checking with the teams of teachers involved was used to verify – and if necessary correct – these initial analyses. In a second round of analysis these verified descriptions of the learning arrangements were used to analyse the types of ICT use that were realised as part of the arrangements, using content analysis (Huberman & Miles, 1994). For this purpose a matrix was constructed combining the school concepts with the variables of ICT use that were mentioned in the previous paragraph, i.e: the ICT tools that were available and used, the goals with which they were used, and the activities in which they were used. After thus analyzing the ICT use per sub case, a cross case analysis per school type enabled us to find patterns in the ICT use related to the school types.

Results

For each school type we first give a short description of the participating schools and their educational concepts. Then, we describe the ICT use that was designed and realised in the schools during the project. In Tables 2 and 3 we give some examples for each school type of the ICT use in terms of the tools that were used, with which goals, and in what kinds of activities. We further characterise patterns in ICT use that were found across the learning arrangements in each school type.

Results: schools with a traditional approach to the curriculum
The ‘traditional’ schools and their educational concepts

The Princess Amalia Primary School (also referred to as school A1) is a growing school in a new suburban neighbourhood. The Alma Mater Primary School (school A2) is a relatively small school in a rural town.

In both schools educational goals are largely pursued through the use of teaching and learning materials with a more or less fixed content. Learning gains are monitored with tests designed for these materials as well as national, standardised tests. Most instruction is given to the whole class, following a more or less strict time schedule, dictated by the teaching materials and the tests that are used. After instruction, pupils mostly work individually or in pairs on assignments (exercises) directly linked to the subject matter. Additionally, remedial instruction is given in smaller groups, informed by test results. Pupils’ activities are mainly determined by the teacher. Sometimes pupils are free to choose who they want to work with. At the Princess Amalia School pupils do much of their work independently, following an individual weekly work plan. This work plan is made by the teacher, yet the pupil is to a large extent free to decide when to work on which assignment. At the Alma Mater School the teacher gives daily assignments to the whole class. Here the teacher determines when the pupils work on which assignment.

ICT use at the ‘traditional’ schools

Both schools designed and realised four learning arrangements in the course of the two-year project, so that a total of eight different learning arrangements could be studied at the ‘traditional schools’. At both schools all learning arrangements were studied in one class per arrangement. All primary grades, from kindergarten to grade 6, were represented in the arrangements studied. Table 2 contains some examples of the ICT tools, the goals and the activities of the learning arrangements at these schools.
Most learning arrangements at both schools involved instruction and learning with standard teaching and learning materials. The tools that were used included software programs (mainly practice software; to a lesser extent also word processing and presentation software), interactive whiteboards and the internet. Observations, teacher

Table 2. Examples of learning arrangements at the ‘traditional’ schools.

<table>
<thead>
<tr>
<th>ICT tools</th>
<th>Working hypotheses</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1-3</td>
<td>Exercise and testing software for reading comprehension</td>
<td>Make exercises more engaging, resulting in higher grades, in particular for lower achieving pupils. Digital tests save teachers’ time.</td>
</tr>
<tr>
<td></td>
<td>Laptop and desktop computers in classroom</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1-4</td>
<td>Internet</td>
<td>Pupils develop web skills: searching, reading search results, and comprehending information. Pupils memorise the information found on the internet. Pupils learn from each other</td>
</tr>
<tr>
<td></td>
<td>Word processing software</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Presentation software</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Laptop and desktop computers in classroom</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2-4</td>
<td>Digital picture books, both ready-made and self-made Interactive whiteboard</td>
<td>Use of digital picture books will increase pupils’ vocabulary more effectively</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
interviews, and analysis of software manuals showed that these tools were mainly used to support the teaching and learning materials. The schools either used existing software developed by educational publishers – in three out of four learning arrangements at both schools – or modified existing materials for the interactive whiteboard (learning arrangements A1-2, A2-3 and 4). For instance where language instruction at the Princess Amalia School was previously given with the help of the traditional blackboard, and exercises done individually by the pupils in their exercise book, the teacher now scans exercises from the book and together with the pupils does some exercises on the IWB, as part of the instruction (A1-2). A similar example we find at the Alma Mater School (A2-3). After the whole-class instruction pupils continue to do the exercises in their book (A1-2) or on the computer (A2-3). Both from lesson outlines and observations we conclude that at these schools the ICT tools that are to be used by the pupils are determined beforehand by the teacher.

The teachers’ working hypotheses reveal that with the increased application of ICT the schools generally aimed at the following goals:

- Making their instruction more engaging or motivating to pupils (all arrangements, A2-2 and 4 to a lesser extent)
- Catering for differences in pupils’ learning abilities (A1-1, and 3; A2-2)
- Maintaining or increasing learning achievements, especially for low-achieving pupils (all arrangements)
- Offering more efficient teaching and learning, leaving the teacher more time for other tasks (A1-1, 2, 3, A2-2, 3, 4)
- Giving pupils a more active role in their learning (A1-1; A1-2; A1-4; A2-1; A2-4).

Based on interviews with teachers we conclude that engaging or motivating their pupils is the ‘traditional’ schools’ main aim of the use of ICT. They expect the variation in instructional and exercise formats facilitated by ICT to contribute to pupils’ motivation. For instance a teacher at the Princess Amalia School says, when describing the expected effects of the use of the IWB in arrangement A1-2: ‘I think it will […] be more fun than
the blackboard, because of the interactivity and sometimes because of the tricks and the things that you show.’ Similarly a teacher at the Alma Mater School says, referring to pupils doing assignments on laptop computers instead of in their exercise books: ‘They are very motivated. They find it a lot of fun when they do it on the laptop’.

Teachers also use ICT to support differentiation, aimed at pupils’ cognitive abilities and pace of learning. Enhancing learning achievements through ICT at the traditional schools is mainly focused on knowledge acquisition and basic skills. Finally, active and self-directed learning is primarily aimed at for the purpose of time efficient learning and teaching. It is mainly designed in terms of doing exercises and assignments on the computer with less assistance from the teacher. Other purposes, like self-directed learning as a skill in itself, are not mentioned by the teachers.

Whole-class instruction and doing exercises (individually or in pairs) are the most prominent ICT-supported learning activities in these schools, as the lesson outlines and classroom observations show. The ‘drill-and-practice’ software that was used at these schools is typically used in such a way that the teacher stays in control of the learning process. Both the teacher and the software determine which exercises the pupils do and when they do them. In some cases the pupils have some freedom in deciding which exercises they want to do. The internet is used sparsely at these schools. When it is used, assignments in the teaching and learning materials specify which information has to be searched by the pupils (A1-4 and A2-1). Teacher interviews and analysis of the manuals of learning materials show that how pupils search the internet is either prescribed (A2-1) or to an extent up to the pupils to decide (A1-4). The same goes for the use of word processing and presentation tools. Classroom observations suggest that there was a slight shift towards more independent work by pupils, mostly in the form of carrying out learning activities with less assistance from the teacher. Teachers confirm this in some of the interviews, for instance at the Alma Mater School, where the teacher used to prescribe exactly which exercises the pupils had to do: ‘They have a bit of freedom in it. With math too. I don’t say: you have to do these exercises. They can choose from five exercises. And with reading as well.’
In all we conclude that both schools designed relatively transparent, straightforward learning arrangements that stayed close to their general didactical principles and curriculum. A limited number of ICT tools was used in each learning arrangement. In general, the ICT tools in both schools were largely used to support learning with standard teaching and learning materials, with mostly fixed learning content and a strongly teacher-directed approach with a little more independent work by pupils.

Results: schools with an innovative approach to the curriculum

The’ innovative’ schools and their educational concepts

The Beehive Primary School (B1) is a relatively new school in a still growing suburban area. It has a team of mainly young teachers and its educational concept is still being developed. The creed that ‘learning can and should be fun’, i.e. meaningful and engaging, plays a major role in this school. Teachers aim to enhance pupils’ sense of involvement and engagement in educational activities, e.g. by letting pupils formulate their own learning goals. Many of the educational activities are organised around the general themes of ‘people and society’ and ‘science and technology’.

The Queen Beatrix Primary School (B2) is located in a small rural village. Before joining this project the school already had the intention to make learning more attractive for pupils, among other things by giving them more control over their learning and by using inquiry projects as learning activities. Science and social sciences are taught in multidisciplinary projects revolving around a certain theme.

The Beech Grove Primary School (B3) is located in a suburban area. The school has recently converted to a new educational concept which puts much emphasis on learning by doing and exploring, giving pupils a lot of freedom to put forward the subjects and questions they wish to explore. Pupils guide and monitor their own learning with the use of a personal portfolio, supported by the teacher.

At all three schools groups are multi-aged, to give pupils the opportunity to learn with and from each other. Standard teaching and learning materials at the innovative schools are mainly used as a general source of content and exercises. At the Beehive School and
the Queen Beatrix School an exception is made for Dutch language and mathematics lessons, for which the curriculum is more strictly prescribed. At the Beech Grove School standard teaching and learning materials are seldom used for any subject.

At the Beehive School and the Queen Beatrix School, after group instruction pupils work on weekly tasks, independently and both individually and in small groups. At the Beech Grove School all subjects are offered mostly in the form of mixed-group workshops from which the pupils can choose. At the Beehive School some of the learning activities take place in the form of such workshops. At the Beehive School and the Beech Grove School the concept of multiple intelligence (Gardner 1999) plays a significant role. Enabling pupils to choose activities that fit their intelligence(s) is expected to make education more meaningful to them.

**ICT use at the’ innovative’ schools**

A total of ten different ‘innovative school learning arrangements’ were studied. The Beehive School realised four learning arrangements. The Queen Beatrix School realised three and the Beech Grove School two of the initial four learning arrangements that were designed, mainly because of the complexity of the learning arrangements that these schools designed. The grades involved at the Beehive School ranged from 1 to 6. At the Queen Beatrix School the classes were multi-aged, grades 4, 5 and 6. At the Beech Grove School both learning arrangements were studied in four multi-aged classes, grades 1, 2 and 3. For each school Table 3 shows an example of the ICT tools used in the learning arrangements, and the goals and activities that were involved.
Table 3. Examples of learning arrangements at the ‘innovative’ schools.

<table>
<thead>
<tr>
<th>ICT tools</th>
<th>Working hypotheses</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1-4 Digital photo camera</td>
<td>Taking photos of groups of objects and using the photos enable pupils to grasp the basic principles of multiplication tables.</td>
<td>Pupils (pairs, small groups) photograph groups of objects. Teacher prints photographs. Pupils use photographs to make multiplication booklets.</td>
</tr>
<tr>
<td>B2-3 Digital photo cameras</td>
<td>When the teacher pays more attention to the explorative learning process, pupils’ learning experiences improve.</td>
<td>Workshop on web searching. Pupils (individually or in pairs) formulate a research question related to the theme ‘the Caribbean’ and carry out a small research project, mainly on the Web. Pupils present their results to the class on IWB or on wall posters.</td>
</tr>
<tr>
<td>B3-2 Internet</td>
<td>More focus on multiple intelligences will help to make more use of them in relation to ICT.</td>
<td>Workshop on multiple intelligences. Teachers give proactive guidance on the use of ICT connected to multiple intelligences. Pupils (individually or in pairs) formulate a research question on a subject of their choice and carry out a small research project.</td>
</tr>
</tbody>
</table>

Classroom observations, teacher interviews and diaries show that mainly open-ended tools were used in the learning arrangements at the innovative schools; i.e. tools that do not prescribe a certain outcome. The Beehive School designed three learning arrangements.
arrangements in which the use of visual tools – i.e. tools for producing digital images – played a major role, as part of the school’s emphasis on the use of multiple intelligences. The interactive whiteboard too, played a prominent role in this ‘visualisation’ of learning material. For instance in learning arrangement B1-1 pupils took photographs of each other’s facial expressions which were then shown on the IWB and discussed with the class. The internet and software for making presentations were used to a lesser extent.

At the Queen Beatrix School and the Beech Grove School emphasis is put on tools that can be used for explorative activities like the internet and microscopes. Explorative activities were also supported by the use of digital cameras, for instance where pupils would take pictures of old houses when exploring building styles from the past (B2-2). None of the learning arrangements studied at the innovative schools were linked to the use of standard teaching and learning materials.

Pupil and teacher interviews show that pupils were largely free to decide which tools to use for their research projects (Queen Beatrix) or were encouraged to use tools connected to multiple intelligences (Beech Grove), like using the computer for making a cartoon based on a textual description of volcanism on the internet (B3-2). At all three schools pupils frequently gave presentations with the use of an interactive whiteboard, mostly without help or interference from the teacher, as in most cases the pupils operated the IWB themselves and led a classroom discussion afterwards, while the teacher remained in the background.

The teachers at the ‘innovative’ schools expressed as a general expectation of ICT that it will make learning activities and content more meaningful and engaging to pupils. As reflected in the teachers’ working hypotheses this effect was expected to be achieved through the following goals:

- Increasing the active construction of learning content by the pupils (B1-1, 2, 4; B2-2, B2-3, B3-1, B3-2)
- Facilitating the production of visual materials and having pupils use these self-made materials as learning materials (B1-1, 2, 4; at B2: all)
• Giving the pupils more opportunities to use multiple intelligences (B1-1 through 4, B2-1, B3-1, B3-2)
• Giving the pupils more opportunities to take their own research questions as the starting point for largely self-directed learning activities (B1-1, 2; at B2 and B3: all).

Although teachers did express the expectation, both in their working hypotheses and in interviews, that pupils would gain knowledge of the school subjects in question, strictly content-related learning goals like memorizing information or increasing vocabulary played only a minor role in these schools' learning arrangements. With regard to learning gains the focus lay on construction of knowledge by producing and discussing visual material and collecting information, mainly on the internet, and the development of skills, like inquiry skills. From the teacher interviews we conclude that at the ‘innovative’ schools ICT was expected to give pupils more control over the content of their learning activities, for instance by giving pupils the opportunity to formulate their own research questions for their inquiry activities. This is also expected to lead to more motivation in pupils, as illustrated in the following quote of a teacher at the Queen Beatrix School, regarding an inquiry activity on the internet: ‘Seeing that children are moved by a subject and then go for it. And at some point you notice that the time is up because they want to do so much. Then you have a good process going on.’ The focus on multiple intelligences at the Beehive School and the Beech Grove School and on pupils’ input in their inquiry activities at the Queen Beatrix School and the Beech Grove School suggests that the innovative schools mainly use ICT to differentiate between pupils in terms of differences in learning style and interest.

The ICT tools that were used were mainly expected to contribute to creating more engaging learning activities. From teacher interviews and classroom observations in all three schools we conclude that the general assumption was that by experiencing the activities and their content as meaningful, the subject matter of the activities would be learned. As the teacher involved in B1-1 – in which the pupils made pictures of each other’s facial expressions – puts it: ‘The best thing was, when they were looking back [to the pictures]. For the children it is somehow so impressive to see yourself on a big
screen, on the IWB. Yes, that brings up so much emotion that you think: this is something they will remember. Because they are in it themselves.’

Classroom observations, teacher and pupil interviews and teacher diaries show that in general the pupils had a lot of input in the ICT-supported activities. At the Beehive School the teacher decided which tools were to be used. Here the pupils’ input mainly concerned the content of their activities, like choosing which objects they made pictures of with the digital camera.

At the Queen Beatrix School and the Beech Grove School to a large extent pupils decided both about the subject of their inquiry activities and the tools that they used for their inquiries.

We further notice that the innovative schools developed complex learning arrangements, involving a wide variety of ICT-supported activities with which the teachers and pupils often had little previous experience, like putting digital pictures on a weblog. This resulted in a relatively large amount of time spent on experimenting with the tools and dealing with technical and organisational problems, e.g. incompatible software or pupils uploading pictures and forgetting on which laptop computer they saved them. Because of time constraints some of the planned activities were therefore not carried out.

We can conclude that at the ‘innovative’ schools in this study ICT tools were generally used to support open-ended activities with a lot of input from the pupils, which the teachers expected to promote the meaningfulness of learning activities. Most learning activities were explorative or concerned the use of multiple intelligences, or both. At one innovative school visualisation of content was a main issue. At all ‘innovative’ schools the control of the learning process within the developed learning arrangements was shared by teacher and pupils. The complexity and novelty of the learning arrangements, made integrating the use of ICT more difficult at these schools than at the ‘traditional’ schools.
Conclusion and discussion

In this study five primary schools were followed while they were supported in developing their educational use of ICT in line with their educational concept. Two schools were labelled as ‘traditional’, i.e. with a fixed, textbook and teacher-driven curriculum and learning activities and content that are set by the teacher and the teaching and learning materials. Three schools were labelled as ‘innovative’, meaning they have a more open curriculum and pupils at these schools have more input in decisions about learning activities and content. The purpose of this study was to characterise the ICT use developed in the five schools, thus answering the question to what extent this concept-guided approach leads to distinguishable types of ICT-use.

The learning arrangements that were designed by the schools with a traditional approach to the curriculum stayed close to the schools’ general didactical principles and curriculum. In most learning arrangements only one or two ICT tools were used, mainly supporting the use of standard teaching materials with fixed learning content and a strongly teacher-directed approach. The learning activities focused on making the instruction more engaging for pupils and offering them more opportunities to practise. There was also some tendency to use ICT to enable more independent work by pupils. Integrating the ICT-enhanced learning arrangements into the existing teaching practice was relatively easy at these schools, with only minor technical problems.

At the three schools in this study that were labelled as ‘innovative’, a wide range of ICT tools was generally used to support open-ended activities with considerable input from the pupils. In this way learning activities were expected to become more meaningful for pupils. Most learning activities were explorative and/or concerned the use of multiple intelligences. At one school visual tools played a significant role, at the other schools the internet and other tools that facilitate explorative activities were used most prominently. The complexity and novelty of the learning arrangements that seemed to be typical of the ‘innovative’ schools made integrating the enhanced use of ICT at these schools more problematic and time-consuming.
The above leads us to conclude that concept-guided development of ICT-enriched learning arrangements indeed resulted in clearly distinguishable types of ICT use in the two types of schools. The tools that were used, the activities in which they were used and the goals that were expected to be achieved through the learning arrangements, in general reflect the different school concepts that set the school types apart. Some ICT tools were used in both school types, yet in different ways, in line with the schools’ different educational concepts. This concerned mainly the basic hardware tools like (laptop and desktop) computers and the IWB, and in a lesser degree the internet.

The teachers in both school types to an extent also formulated similar goals. In all five schools teachers to some measure expected the ICT-enhanced learning arrangements to increase pupils’ motivation, improve learning results, promote self-directed learning, and enable teachers to differentiate more between pupils. Yet the different ways in which the same tools were used in the different school types indicate that the schools hold significantly different expectations with regard to ICT and learning. At the traditional schools enhanced motivation was expected because of the variation in instructional and exercise formats facilitated by ICT, whereas the innovative schools’ teachers expected pupils to be more motivated through the enhanced meaningfulness of learning activities enabled by the ICT applications. With regard to learning results the traditional schools focused on knowledge acquisition through ICT, while the innovative schools expected the intensified use of ICT to contribute mainly to the development of skills, like inquiry skills. As for self-directed learning, at the traditional schools this meant in most cases doing exercises and assignments on the computer with less assistance from the teacher, whereas at the innovative schools ICT was expected to give pupils more control over the content of their learning activities, like in inquiry projects. Finally, the traditional schools designed ICT-enhanced learning arrangements that enabled differentiation with respect to learning abilities (cognitive level and learning pace), while at the innovative schools differences in learning style and interest were facilitated by the use of ICT.
One significant difference between the school types was, as stated above, that the traditional schools created learning arrangements that were relatively easy to integrate into their educational practice. For those involved in concept-guided ICT development in innovative schools it is important to note that the more complex learning arrangements designed in these schools may typically take more time and support to develop and implement and ask more motivation and perseverance from teachers.

We conclude this article with some suggestions for further research. In this explorative study only five schools, roughly characterised as either traditional or innovative, were followed in the process of developing and enacting ICT-enriched learning arrangements. This gave us the opportunity to study in detail the learning arrangements that materialised at these schools as a result of concept-guided development of ICT use and to give a detailed characterisation of the ensuing uses of ICT. A more large scale approach could give a view of a wider range of educational concepts and their characteristic uses of ICT, making these results generalisable to a wider range of educational practices. A longitudinal study could also focus on the durability of the accomplished integration.

Finally, the practical implications of the complexity of the ICT-enhanced learning arrangements developed by the innovative schools, and the subsequently more challenging integration of the ICT use warrant further study.
Chapter 3  Interactivity with the interactive whiteboard in ‘traditional’ and ‘innovative’ primary schools: An exploratory study

One of the main affordances of the interactive whiteboard (IWB) is its potential for increasing classroom interactivity, yet little is known about the interactivity it supports in schools with different educational concepts. In this study we analysed what types of whole-class interactivity the IWB supports in schools with either a traditional or an innovative school concept. Interactivity was operationalised in terms of operation of the IWB, control of the IWB content, and the whole-class dialogue. A cross-case analysis of videotaped lesson observations revealed patterns in the interactivity related to school type. Comparison of the prevalent interactivity patterns at the two school types shows that students at the innovative schools had a more active role in the content of the IWB-supported lessons than those at the traditional schools. The students at the traditional schools operated the IWB more often, which coincided, however, with little or no student control of the IWB content and with whole-class dialogue that focused on knowledge transmission. At the innovative schools the active student role regarding lesson content did not coincide with student operation of the IWB. These findings indicate a link between the school’s educational concept and the type of interactivity in IWB-supported lessons.

Introduction

Over the past decade the interactive whiteboard (IWB) has proved to be a valuable tool for teaching and learning. Earlier research on the use of the IWB as a pedagogical tool

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3 This chapter is based on: de Koster, S., Volman, M., & Kuiper, E. (2013). Interactivity with the interactive whiteboard in traditional and innovative primary schools: An exploratory study. Australasian Journal of Educational Technology, 9(4), http://dx.doi.org/10.14742/ajet.291
mainly explored the potential it might hold for education, as Glover, Miller, Averis, and Door (2005) show in their literature review. More recent studies focus on the advantages and disadvantages of the IWB as an educational tool (Cutrim Schmid, 2008; Slay, Siebörger, & Hodkginson-Williams, 2008; Somyürek, Atasoy, & Özdemir, 2009) or investigate how the IWB is actually being used in pedagogical settings (Smith, Hardman, & Higgins, 2006; Haldane, 2007; Kershner, Mercer, Warwick, & Staarman, 2010). Findings suggest that the IWB can be used to support different types of classroom interactivity. Although Smith et al. (2006) find in their study that the IWB is mostly used for whole-class teaching with a relatively high pace and frequent yet short student answers, other studies show that it can support both a teacher-directed and a more student-directed pedagogic approach to whole-class teaching (Gillen, Kleine Staarman, Littleton, Mercer, & Twiner, 2007). In this study we investigate what types of interactivity occur in IWB-supported lessons in schools with either a teacher-directed pedagogy or a student-directed pedagogy.

Classroom interactivity supported by the IWB

After the introduction of the IWB into the classroom arena, most studies focused on the use of the IWB to support whole-class lessons (Kershner et al., 2010). More recent studies focus on the use of the IWB in individual and group work by students as well, for instance in collaborative tasks in which children share ideas about a topic (Kershner et al., 2010; Warwick, Mercer, Kershner, & Kleine Staarman, 2010). Its potential for supporting classroom interactivity is one of the main reasons given by teachers for adopting the IWB (Smith, Higgins, Wall, & Miller, 2005; Kennewell, Tanner, Jones, & Beauchamp, 2008). In the analysis of classroom interactivity supported by the IWB it has become customary to take both the technical and the pedagogical dimensions of the interactivity into account (cf. Smith et al., 2005; Kennewell et al., 2008). The technical dimension of interactivity – often referred to as technical interaction – relates to the operation of the board by the teacher and/or students, like browsing the internet or showing and processing images or text (writing, drawing, dragging, clicking, et cetera). The pedagogical dimension of the interactivity – or pedagogical interaction – on the
other hand encompasses all elements of the interactivity among teacher and students (or among students) that serve a pedagogical purpose (Smith et al., 2005; Evans & Gibbons, 2007). This dimension includes the teacher’s pedagogical decisions that relate to technical interactions with the IWB, like whether or not to give students the opportunity to operate the board or to have control of the content on it. It also includes classroom dialogue about subject matter.

*Interactivity in different models of learning and instruction*

In the literature we find high expectations of how increased interactivity can engage students in their learning process in a more active way (cf. Beauchamp & Kennewell, 2010). One of the rationales behind these expectations is the assumption that actively engaged students have a higher learning motivation, which increases learning results (Beeland, 2002; Torff & Tirotta, 2010; Hennessy, Deaney, Ruthven, & Winterbottom, 2007; Slay et al., 2008). Another rationale is the assumption that learning by definition implies a process of knowledge construction in which the student plays an active role (Jonassen, 1992; Mayer, 2001). Classroom dialogue is one of the key aspects of classroom interactivity (Wells & Arauz, 2006). In classroom dialogue it is traditionally the teacher who initiates the exchange and takes on the role of didactic expert (Smith et al., 2006) or "primary knower" (Nassaji & Wells, 2000, after Berry, 1981). The teacher transmits information through lectures. Subsequently the teachers' questions in this type of dialogue are primarily aimed at recitation of previously memorised information. Students' responses are evaluated in terms of correctness or conventionality (Mroz, Smith, & Hardman, 2000). This division of roles reflects the traditional division of power between teacher and students (Lemke, 1990), also associated with the instructional model of knowledge transmission. Nassaji and Wells (2000) point out that control is divided more equally if the teacher does not claim the role of didactic expert or primary knower. In that case the teacher asks more open questions and focuses on promoting understanding rather than transmission and recitation of information. This approach rather reflects the instructional model of knowledge construction (Rogoff, 1994).
Thus the nature of classroom dialogue and hence classroom interactivity appears to vary with the model of learning and instruction that underpins the learning activity in which the interactivity occurs. As the IWB can be used in very diverse pedagogical ways (Winzenried, Dalgarno, & Tinkler, 2010) it can reasonably be expected to support different types of interactivity in schools with different educational concepts.

**Concept-guided development of ICT use**

Research shows that a significant condition for the successful integration of information and communication technology (ICT) into the classroom is that the intended ICT use fits the school's educational concept. Zhao, Pugh, Sheldon, and Byers (2002) in this respect mention the importance of a minimal distance between an ICT innovation and the school's culture, i.e., the school's "dominant set of values, pedagogical beliefs and practices", while Tolmie (2001) points at the fit between the ICT resources that are used and the school's "established patterns of activity". Niederhauser and Stoddart (2001) stress that teachers are inclined to apply technology in a manner that is consistent with their "personal perspectives about curriculum and instructional practice". Developing ICT use in a "concept-guided" way promotes this fit between pedagogy and technology (de Koster, Kuiper, & Volman, 2012). Concept-guided development implies that the school's existing concept is clarified and that possibilities are explored to develop ICT use that supports this concept. By concept we mean a school’s classroom practices (cf. patterns of activity) and the educational views (values, beliefs, and perspectives) underpinning these practices. A previous study (de Koster et al., 2012) showed that this approach leads to clearly distinguishable types of ICT use, in line with the type of education that the school is aiming to provide. It is, therefore, to be expected that when schools develop their ICT use in a concept-guided way, the use of the IWB for supporting classroom interaction will vary according to the school's educational concept.

**Method**
The four schools in this study participated in a project in which ICT use was developed in a concept-guided way. The participating schools, classified as either traditional (mainly teacher directed) or innovative (mainly student directed), each developed a number of ICT-rich learning arrangements in a concept-guided way. Each school type developed a distinguishable type of ICT use (de Koster et al., 2012). However, one tool that was included in learning arrangements across the school types was the IWB. As the IWB can be expected to support different types of interactivity in schools with different educational concepts, this aspect of IWB use became the focus of our investigation. So far the types of interactivity supported by the IWB in schools that develop their use of the IWB in a concept-guided way had not been investigated. The main research question for this study was: What types of classroom interactivity does the IWB support in traditional and innovative schools that develop their ICT use in a concept-guided way? Classroom interactivity in this context refers to all pedagogical interactions in whole-class situations, both with the IWB and in teacher-student dialogue. We focus on whole-class lessons, as the schools in this project all primarily used the IWB to support whole-class teaching.

**Participants and setting**

The four schools in this study participated in a project in which they developed ICT use in a concept-guided way. The participating schools had educational concepts that were labelled as either traditional or innovative. The traditional label refers to a fixed curriculum and a strongly teacher-directed approach, while the innovative label indicates a more open curriculum with a focus on self-regulated learning. Of each school type two schools are represented in this study. The two traditional schools follow a mainly textbook-driven curriculum, with relatively little input from the students. Whole-class, direct instruction is the main form of instruction. After instruction, pupils individually or in pairs process the lesson content in highly structured exercises and assignments. The two innovative schools have a more open curriculum. Students at these schools have more input in learning content and activities, often working on research projects that start from their own research questions. Whole-class instruction is
less predominant; students typically spend most time working in small groups or individually, while the teachers often take on a coaching role. Video observations of six lessons in six different classes across both school types were analysed. Each analysed lesson took place in the context of a different learning arrangement. The lessons were given by five different teachers; of one teacher two different lessons in two subsequent school years were analysed. The grade levels varied from second to sixth grade. Class sizes varied from 13 to 28 students.

Procedure and design

In the course of two school years the schools in this study each designed, developed and implemented up to four ICT-enhanced learning arrangements. The schools developed these learning arrangements in a concept-guided way, meaning that a team of teachers at each school was supported in designing and implementing learning arrangements in line with their school's educational concept (cf. de Koster et al., 2012). The teachers were supported by educational counsellors specialised in guiding innovation projects. With these counsellors the teachers reflected on their school's educational concept and its ambitions for intensifying its use of ICT in line with this concept. This way we expected the schools' educational concepts to be reflected in the resulting ICT-enhanced learning arrangements.

Data collection

Several lessons in each learning arrangement were observed and in most cases recorded on video. For this study we selected three videotaped lessons per school type that were likely to give a meaningful and comprehensive picture of the IWB practices at the different school types. Most IWB-supported lessons mainly comprised whole-class interactions between teachers and students. We selected lessons that included a considerable amount of dialogue between teacher and students in order to study these whole class interactions. The lessons were divided into episodes – i.e., clearly distinguishable parts, divided by for instance a change of topic – of which only the
whole-class episodes were analysed. This led to an analysis of eight whole-class episodes for each school type, 2 to 20 minutes long and with an average of 8 minutes per episode. A total of 128 minutes of observation footage was analysed. Relevant episodes of group or individual work by students are briefly described as part of the context.

Microanalysis: types of IWB-supported interactivity

We performed a microanalysis of the interactivity in the six lessons that were selected, in order to find patterns that would help characterise the interactions in IWB-supported lessons. For this microanalysis all whole-class interactions in the selected episodes were transcribed, including all content-related whole-class dialogue and all technical interactions with the IWB. During the analysis we noted down the following characteristics of each lesson: the subject of the lesson, the grade and the lesson outline, including the general goal of the lesson (covering new subject matter or repeating previously covered content, et cetera), and the main content on the IWB. These aspects functioned as the context necessary for the interpretation of the interactions (Green & Dixon, 2002). With regard to the interactions with the IWB we distinguished two aspects:

1. Operation of the IWB: who operated the board? Either the teacher exclusively operated the IWB (labelled as teacher), or the teacher let one or more students operate the board (student) or both teacher and student(s) operated the board (shared).
2. Control of the content on the IWB: who decided what was written or shown on it? Possible values are teacher if the students had no input in the content on the IWB (e.g., the teacher did not ask for contributions or did not write down students’ contributions), student if all content was provided by the students (e.g., only the students’ contributions were written on the board), or shared in all other cases.
The dialogue was described in terms of the teaching and learning model apparent in the dialogue. This could be labelled as either knowledge transmission (i.e., the teacher primarily transmits information and/or prompts students to recite previously transmitted information) or knowledge construction (i.e., the teacher tries to induce students to think actively and construct knowledge, focusing on understanding rather than recitation). In a cross-case analysis these descriptions were compared in order to find possible patterns of interactivity per school type (Miles & Huberman, 1994). Reliability of both the fragmentation and the analysis was ensured by the creation of an audit trail and discussion of the data with co-researchers to check for agreement (Graneheim & Lundman, 2004).

**Results**

In this section we discuss our findings on the types of IWB-supported classroom interactivity. The lessons at the traditional schools are discussed first, followed by a discussion of the lessons at the innovative schools. Each of the three aspects of interactivity (IWB operation, control of IWB content, and dialogue) is described and illustrated with exemplary excerpts from the observation transcripts. We conclude this section with a comparison of the results of both school types.

*Interactivity in IWB-supported lessons at the traditional schools*

**Descriptions of the lessons analysed**

Lesson 1 consisted of two episodes. In episode 1a the teacher went over spelling rules that had been covered in an earlier instruction lesson and asked some students to do an exercise on these rules on the IWB. In episode 1b the teacher went through some exercises as a preparation for the students' individual work in their exercise books.

Lesson 2 was divided into three episodes. In the first episode (2a) the teacher asked the class to compare two similar texts on the IWB. She then asked a student to show on the IWB how he would look for certain information on a specific webpage (2b). In the third
episode (2c) the teacher asked this student and some other students to type the information they found in their own words in a Word document displayed on the IWB. The teacher herself typed the final sentence, formulated with the students.

Lesson 3 also comprised three episodes. In the first and third episodes (3a and 3c) the teacher discussed a task card that was projected on the IWB. In the second episode (3b) she discussed the outcomes of an exercise from the card with the class.

Table 1 summarises the contextual characteristics of the lessons at the traditional schools.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>School</th>
<th>Grade(s)</th>
<th>Subject</th>
<th>Lesson outline</th>
<th>Main content on IWB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A1</td>
<td>3</td>
<td>Language</td>
<td>Going over previously learned linguistic rules again and doing exercises</td>
<td>Exercises from students’ exercise books and exercises prepared by the teacher</td>
</tr>
<tr>
<td>2</td>
<td>A1</td>
<td>3</td>
<td>Science</td>
<td>Discussion of internet searching in the context of assignments on finding and processing information</td>
<td>Two prepared texts, a webpage and text written by students</td>
</tr>
<tr>
<td>3</td>
<td>A2</td>
<td>2</td>
<td>Science</td>
<td>Introduction of a system of task cards as part of a new science method</td>
<td>Teacher shows a task card</td>
</tr>
</tbody>
</table>

**Interactivity patterns**

Table 2 shows that at the traditional schools the IWB was operated by the teacher in five of the eight episodes, while in three episodes the operation was shared by teacher and
students. With regard to the control of the content on the IWB, we found that in seven episodes the teacher fully controlled the content, while in one episode the control was shared. The dialogue in the lessons at the traditional schools reflected knowledge transmission as the main goal in five episodes, while in three episodes the dialogue was aimed at knowledge construction. The interactivity is summarised in Table 2 and is described in more detail below.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Episode</th>
<th>Operation of IWB</th>
<th>Control of IWB content</th>
<th>Type of dialogue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a</td>
<td>Shared</td>
<td>Teacher</td>
<td>Transmission</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Transmission</td>
</tr>
<tr>
<td>2</td>
<td>a</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Transmission</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>Shared</td>
<td>Teacher</td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>Shared</td>
<td>Shared</td>
<td>Construction</td>
</tr>
<tr>
<td>3</td>
<td>a</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Transmission</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Transmission</td>
</tr>
</tbody>
</table>

**Operation of the IWB**

During the introduction to the exercise on the IWB in episode 1a, the teacher operated the board herself. The exercise consisted of two versions of twelve words across two columns. Each word was spelt correctly in one column and incorrectly in the other. The students had to identify the correct word and click on it. For each word pair the teacher asked a student to come to the IWB. If necessary the teacher assisted the students in operating the board. In episode 1b the teacher went through the exercises that the students were going to do individually in their exercise books. She had scanned these exercises, primarily fill-in exercises, from the exercise book and projected them on the IWB. For each exercise the teacher filled in at least one outcome on the IWB.
In lesson 2 the students first responded to two texts that the teacher projected on the IWB (2a). The teacher then asked one student to navigate a webpage on the IWB to show how he would look for certain information on that page (2b). In episode 2c this student and some other students typed the information they had found in their own words in a Word document displayed on the IWB. The teacher concluded this lesson by typing a final sentence, with input from the students.

In lesson 3 the teacher operated the board herself throughout the whole lesson. The intensity with which the IWB was used was relatively low, as the teacher only used it to project the digital version of the card that she was discussing with the class and to point at the text and symbols shown on the card when referring to them. During the second episode (3b) the IWB was not referred to, although the teacher did ensure that the task card remained on the screen when it went into stand-by mode after a while.

**Content on the IWB**

The teacher mainly determined the content on the IWB in all three lessons at the traditional schools. In lesson 1 the teacher selected and prepared the exercises that she and the students did on the IWB. The exercises have a closed character, with only one correct answer. In episodes 2a and 2b of lesson 2 the content on the IWB consisted of two similar texts about castles, written by the teacher, and a preselected page from a website. The teacher prepared all of the content in these two episodes. In episode 2c the assignment in which students wrote the information they had found in their own words was more open-ended, thus giving the students more control of the content. Within the context of the preselected webpage they could decide which information they found most important and use their own words to reformulate this information. In lesson 3 the content on the IWB only comprised the task card that was discussed, giving the students no control of the content at all. In episode 3b the teacher did not write students' answers on the IWB.

**Dialogue**
The dialogues in most of the episodes at the traditional schools consisted of knowledge transmission by the teacher and prompting of student recitation. In lesson 1 the teacher checked how well the students had memorised and understood the linguistic rules learnt in a previous lesson. She only asked for conventional answers, testing the students' ability to give the conventional explanations of grammatical terms (example 1.1) and to apply the rules they had learned in the exercises (example 1.2).

**Example 1.1**
The IWB shows two columns of words with the names of two spelling rules at the top. There is a grey bar above the names of the rules.

**Teacher**  
[...] I would like to hear it once more.  
Who can tell me what the acorn rule is. Do I see all hands go up? Almost.  
Vincent.

**Student**  
After a long sound, one consonant.

**Teacher**  
You know it.  
Now I wonder...  
Clicks on the grey bar on the board; the rule appears

Wow. Long sound, one consonant.

**Example 1.2**
The same two columns are on the IWB. After explaining the exercise to the students the teacher asks one of them to do the first word.

**Teacher**  
Do we get it? Okay, David, can you read the next two words out loud?

**Student**  
Ontdeking [discovery, misspelled]  
Ontdekking [discovery, spelled correctly]

Teacher points at the words, following the student's reading pace

**Teacher**  
Well, show us what you think.
In the first episode of lesson 2, in which the students had to identify the differences between the two texts on the IWB, the teacher asked the students seemingly open questions. Yet as the lesson unfolded it became clear that she was looking for one specific answer, namely that the main difference was that difficult words, i.e., academic language, were used in one of the texts, while the other text was written in words that students would use themselves, i.e., language appropriate for this age group (example 1.3).

*Example 1.3*

The teacher first projects a short text about castles on the IWB, written by herself in academic language. She asks the students to read it for themselves and to say what they think of it and why. The students mention the use of difficult words and the teacher keeps asking for other criteria. She then projects a second text about the same subject, also written by herself but in more accessible language. Again she asks the students for their opinion.

Teacher  
Student  
Teacher  
Student  
Teacher  
Student
here they explain more. For example, what's an entrance, well, that's a thing for … it's a castle's door.

Teacher    Almost right

Student    Yes, opening. And it's written in ordinary words.

Teacher    [points at student] I think it's great that you say that, in ordinary words, yes.

In episodes 2b and 2c the teacher's questions became more genuinely open-ended and more focused on students’ own explanations and thus on knowledge construction by the students. In episode 2b the teacher asked the student at the IWB to show how he would look for specific information on the webpage (example 1.4).

**Example 1.4**
The teacher has opened a webpage about castles on the IWB. She asks a student how he would search the page for information on how a castle is built and asks him come to the board to demonstrate his search strategy.

Teacher    Who can tell us, say we're going to do this in a minute, on the computer, what do I start with? What am I going to do first?

Student    Look for information […]

Teacher    Yes, I have that here. Tell me what I should do then. [Reading from the board:] How is a castle built?

Student    Then you read everything that it says, and
then…

Teacher: Am I going to read everything?
Student: No…

Teacher: So from top to bottom I'm going to read all this. Scrolls down to end of the page and back up
Student: No, then you look for the chapter how is a castle built?
Teacher: Right. Can you look that up for us? […] Get a chair. [Hands student the digital pen]

Student: Starts scrolling down through the text; looks at the text as it moves up the screen

Teacher: What are you looking for now? What are you looking at?
Student: How a castle is built, at the chapter titles.
Teacher: [Taking a step towards the board] Right. So you look at the red letters, at the titles, whether you can find a title about building a castle. Very good.

In episode 2c the teacher asked the student at the IWB to write the information he had found in his own words. Two other students were also asked to write a sentence. Because the students' texts immediately appeared on the IWB as they typed, the whole class could closely follow the writing process. Both the class and the teacher commented on what the students were writing as they typed (example 1.5). Students dictated the final sentence while the teacher typed it.
**Example 1.5**

The teacher asks some students to reformulate the information found in their own words and write a sentence on the IWB, using a keyboard in the middle of the classroom connected to the IWB.

**Teacher**  What are you going to type?

**Student**  That below the ground there are traces of wood.

**Teacher**  Yes. You can write that down.

**Student**

[Close-up of board shows that the student makes a mistake in the text and goes back to correct it]

**Teacher**  There's a red line underneath it, what does that mean?

**Student**  Corrects the mistake

**Teacher**  Right, that's very good.

**Student**  Finishes the sentence

In episodes 3a and 3c the teacher read and explained the text on the task card projected on the IWB out loud. In the first episode she also asked some of the students to read part of the text and explain what it says (example 1.6). She corrected the students' reading mistakes without comment. The teacher also demonstrated what the text and icons on the card mean, for instance, by showing them how they could find the right card from the box of task cards.

**Example 1.6**

The teacher asks a student to explain two icons on the task card on the IWB.
Then we see another icon. What does that mean? Two people, Simon?

Well, that you have to work together.

Oh, so working in pairs. So we are going to work in pairs, as I will explain later.

There's a 1. Do we have to do 1 assignment?

No. Grades 1 and 2 have to do it.

Very good.

The next episode (3b) consisted of a whole-class discussion on the outcomes of an assignment in which pairs of students discussed different forms of transport with each other. In this whole-class discussion the teacher gave little feedback on the students' answers, accepting most answers with a short evaluation (example 1.7). She did not write the students' answers on the IWB. Throughout the lesson the IWB only functioned as a means of reference.

*Example 1.7*

The teacher summarises some of the forms of transport that she has heard the pairs of students discussing and then asks students to add to her summary. The task card is still projected on the IWB, but there is no interaction with the board in this fragment.

Now tell me… raise your hand if you know with what other forms of transport you can go on vacation. Mary.

By plane, by car, by bike…

Yes.

On foot. By camper. By… I don't know what it's called. A thing, like…
Interactivity in the IWB-supported lessons at the innovative schools

Descriptions of the lessons analysed

For this study three IWB-supported lessons at the two innovative schools were analysed. Again eight episodes were distinguished. Lesson 4 consisted of two episodes revolving around a presentation by a pair of students, based on a WebQuest they had done about bullying. In episode 4a, which took place just before the presentation, the teacher discussed with these two students and the class how the students had tackled the assignment. In episode 4b, immediately after the presentation, the teacher commented on one of the points that the students made in their presentation.

In lesson 5 the teacher made a mind map on the IWB as an introduction to the new topic of "our house". This lesson consisted of two episodes, the second episode starting with the introduction of a new subtheme by the teacher.

Lesson 6 also mainly consisted of making a mind map. This lesson counted four whole-class episodes. First the teacher discussed with the students the assignment on acquainting themselves with the topic "the Caribbean" by looking for information (6a). The teacher then made a mind map of the information that the students had found during the assignment (6b) and asked the students to formulate research questions based on this mind map. She discussed with the students what criteria a research question has to meet (6c). The students then formulated research questions in pairs that were subsequently discussed during a whole-class discussion (6d).

Table 3 summarises the contextual characteristics of the lessons at the innovative schools.
Table 3  Lessons at the innovative schools: Context information

<table>
<thead>
<tr>
<th>Lesson</th>
<th>School</th>
<th>Grade(s)</th>
<th>Subject</th>
<th>Lesson outline</th>
<th>Main content on IWB</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>B1</td>
<td>2/3/4</td>
<td>Science</td>
<td>A presentation of students' research results; discussion of the process of research and making the presentation</td>
<td>WebQuest, slideshow in PowerPoint</td>
</tr>
<tr>
<td>5</td>
<td>B2</td>
<td>4/5/6</td>
<td>Science</td>
<td>Exploration of new topic</td>
<td>Teacher makes a mind map</td>
</tr>
<tr>
<td>6</td>
<td>B2</td>
<td>4/5/6</td>
<td>Science</td>
<td>Exploration of new topic and formulation of research questions by students</td>
<td>Teacher makes a mind map and writes students' research questions on IWB</td>
</tr>
</tbody>
</table>

Interactivity patterns

The teacher operated the IWB in seven of the episodes at the innovative schools, while in one episode the operation of the IWB was shared. In none of the episodes was the IWB operated only by students. Both teacher and students determined the content on the IWB together in seven episodes, while in one episode the content was fully determined by the teacher. No whole-class episodes with fully student-controlled IWB content were observed. The whole-class dialogue at the innovative schools was exclusively aimed at knowledge construction in all eight episodes. Table 4 summarises these findings and they are described in more detail below.
Table 4   Overview of interactivity patterns per aspect at the innovative schools

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Episode</th>
<th>Operation of IWB</th>
<th>Control of IWB content</th>
<th>Type of dialogue</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>a</td>
<td>Shared</td>
<td>Shared</td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>Teacher</td>
<td>Shared</td>
<td>Construction</td>
</tr>
<tr>
<td>5</td>
<td>a</td>
<td>Teacher</td>
<td>Shared</td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>Teacher</td>
<td>Shared</td>
<td>Construction</td>
</tr>
<tr>
<td>6</td>
<td>a</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>Teacher</td>
<td>Shared</td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>Teacher</td>
<td>Shared</td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>Teacher</td>
<td>Shared</td>
<td>Construction</td>
</tr>
</tbody>
</table>

Operation of the IWB

During episode 4a the teacher and the students who had made the presentation operated the IWB together. The teacher operated the IWB in reaction to what the students said. For instance, when the students mentioned the WebQuest that led to their presentation the teacher used his laptop computer to open this WebQuest on the IWB. During episode 4b the teacher operated the IWB, this time to go back to a slide that he wanted to discuss with the students. In lessons 5 and 6 the IWB was only operated by the teachers, who wrote the students' contributions on the board. In lesson 5 the teacher decided twice that the page had become too full and opened a new mind map. In lesson 6 the teacher used the IWB to project a clock (6a and 6c), to make a mind map (6b) and to write students' research questions (6d).

Content on the IWB

In lesson 4 the content on the board was alternately provided by the students and the teacher. The students provided most of the content on the IWB in lessons 5 and 6. In lesson 5 the students provided keywords for the mind map that they associated with the topic "our house". In episode 5a the teacher divided the mind map into categories, some
of which were suggested by students. The teacher discussed with the students which category a keyword belonged to. When the page become too full the teacher opened a new mind map and entered the students’ contributions (5b).

In episode 6a the teacher used the IWB for projecting a clock, indicating the time the students had for this assignment. In the next whole-class episode (6b) the teacher used the IWB to write keywords from the information students had found. Some of the keywords were formulated by the students, sometimes slightly modified by the teacher. In episode 6c the teacher again projected a clock on the IWB for the next assignment. After group work on formulating research questions the teacher wrote the students' research questions on the board during a whole-class discussion (episode 6d).

**Dialogue**

In episode 4a the teacher played an active role, mainly focusing on the process of performing a WebQuest and making a presentation. He asked the students who had made the presentation to clarify what they had done. The teacher then explained the activities to the youngest students or asked other students to explain. He summarised or further clarified students' answers and explanations (example 2.1). In episode 4b the teacher discussed a suggestion for further research with the students who presented their research results.

**Example 2.1**

The teacher asks the students who made the presentation to explain how they have found the information that they are about to present to the class.

Teacher  
Okay, so you started with a mind map.

Students  
Yes, we started with a mind map…

Teacher  
[to the class] Who can tell me why they started with a mind map? Grade 4 students know this, I wonder if grade 2 and 3 students also know.

Student 1  
Then they could first learn something and… I can't
Teacher: Who can explain?

Student 2: Because then you learn more about the topic…

Teacher: That's not completely correct, because you don't look for information to put in the mind map.

Mickey?

Student 3: Well, you make the mind map because it has things that you haven't looked up but that you already know about bullying and you look up that which you don't know so much about.

Teacher: Okay, well said. So you use a mind map to arrange your thoughts. What do I already know? And you also find out what you don't know yet. And that's what you can then research.

Most of the whole-class dialogue in lesson 5 and a considerable amount of lesson 6 (episode 6b) revolved around the mind maps on the IWB. In lesson 5 the mind map served the goal of activating students' prior knowledge. In episode 6b the students' contributions were based on their internet search assignment at the beginning of lesson 6. Both teachers sometimes asked the students to clarify their contributions for the mind maps (example 2.2) or how the keyword was spelled before writing it down.

**Example 2.2**

In lesson 5 the teacher asks the students to provide keywords for the mind map on the topic "our house".

Teacher: Lucas.

Student 1: Bay window.

Teacher: What is a bay window?

Student 1: [tries to explain what he means, inaudible]

Teacher: [Repeating the student's response, jokingly] A
circle at your house. So you put all your chairs in a circle?

Student 1 [tries to explain with gestures what he means]

Student 2 Like an annex thing.

Teacher So a bay window is an annex. It's not exactly the same. An annex isn't necessarily a bay window, but a bay window is a kind of annex.

In episode 5a the teacher divided the mind map into categories. She often referred to these categories and actively involved the students in using the categories, for example by asking them which category their contribution belonged to (example 2.3).

*Example 2.3*

In lesson 5 the teacher asks the students to provide keywords for the mind map on the topic our house.

One of the mind-map categories was 'construction'.

Student Iron.

Teacher Where do you want me to put that?

Student Well, there at the construction of the house. Because sometimes they have iron beams [...].

Teacher I'll write iron beams. Teacher writes ‘iron beams’

In episode 6a the teacher explained the assignment on searching for information about the topic "the Caribbean" and asked the students where they thought they could find this information. In episode 6c, before the students started to formulate research questions, the teacher asked them to sum up criteria for a good research question (example 2.4) and she negotiated with them
on the amount of time they were going to need to formulate good research questions of their own.

*Example 2.4*

In lesson 6 the teacher asks the students what criteria a good research question must meet, before starting to think of their own research questions. She elaborates on the students’ answers.

Student: That you know exactly what you want to know.

Teacher: That you know exactly what you want to know. So it should not be a very general question. Judy?

Student: A question that you don't know yourself.

Teacher: Very good. To which you don't know the answer yet. Because otherwise it's no use. Then you already know it, so you don't want to investigate it.

*Comparison of interactivity patterns between school types*

Tables 2 and 4 show the following interactivity patterns. The most common interactivity pattern at the traditional schools consisted of teacher operation of the IWB together with teacher-controlled IWB content, and dialogue that focused on knowledge transmission. This pattern was evident in four out of eight episodes. Four other patterns were found that showed a more active role of the students, in terms of operation of the board (three episodes), IWB content (one episode) and/or dialogue characterised by knowledge construction (three episodes). All eight episodes at the innovative schools showed a focus on knowledge construction. In six episodes this was combined with teacher operation of the IWB and shared control of IWB content. In one episode both the operation of the IWB and control of IWB content were shared, while in one episode both were teacher controlled.
Two patterns were found at both school types, each occurring once. In both the traditional and the innovative schools we found one episode in which the teacher operated the IWB and controlled the IWB content, while aiming at knowledge construction. The other pattern, also found in one episode in each school type, consisted of shared IWB operation and control of IWB content combined with dialogue characterised by knowledge construction. Table 5 shows these patterns and their frequencies.

<table>
<thead>
<tr>
<th>Interactivity per aspect</th>
<th>Frequency per school type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Traditional</td>
</tr>
<tr>
<td>Operation IWB</td>
<td>Control IWB content</td>
</tr>
<tr>
<td>Teacher</td>
<td>Teacher</td>
</tr>
<tr>
<td>Teacher</td>
<td>Teacher</td>
</tr>
<tr>
<td>Teacher</td>
<td>Shared</td>
</tr>
<tr>
<td>Teacher</td>
<td>Shared</td>
</tr>
<tr>
<td>Shared</td>
<td>Teacher</td>
</tr>
<tr>
<td>Shared</td>
<td>Teacher</td>
</tr>
<tr>
<td>Shared</td>
<td>Shared</td>
</tr>
<tr>
<td>Shared</td>
<td>Shared</td>
</tr>
</tbody>
</table>

These differences between the school types might partly be related to student age, since at the traditional schools only grades 2 and 3 are represented in the study while at the innovative schools grades 2 through 6 were included (see Tables 2 and 4). However, the most prominent interactivity pattern found at the innovative schools was observed across all grades represented in the study. This reinforces the impression that the found differences can be attributed to the schools' educational concepts rather than student age.

**Conclusion**
In this study we explored what types of classroom interactivity the IWB supported in four schools that developed their ICT use in a concept-guided way. Two schools had a traditional educational concept, characterised by a mainly textbook-driven curriculum, direct instruction and highly structured exercises. The other two schools had an innovative concept, characterised by a more open curriculum, with more input from students and a coaching role for teachers. We looked for patterns of interactivity within and across these two school types. We analysed the interactivity with the IWB in terms of who operated the board and who was in control of the content on the board. We further analysed whether the dialogue during the IWB-supported lessons focused on transmission or construction of knowledge.

Based on their educational concepts, one would expect the IWB operation and content at the traditional schools to be mainly teacher-controlled and dialogue to be directed at knowledge transmission, while at the innovative schools the IWB use could be expected to be mainly student-controlled and dialogue to be focused on knowledge construction. Our findings, however, are not that unequivocal. In the lessons at the traditional schools the most common interactivity pattern found was teacher operation of the IWB together with teacher-controlled IWB content and dialogue that focused on knowledge transmission, as could have been anticipated. Yet other patterns, with a more active student role, were found as well. And even though the innovative schools' educational concept would suggest an active role for students, surprisingly in most episodes the teacher operated the board, while sharing control of IWB content with the students. Dialogue was focused on knowledge construction as could have been expected.

These findings firstly indicate that the use of the IWB did indeed occur with distinguishable typical patterns of interactivity that varied between these two school types. Secondly, our findings also show that the IWB-supported interactivity was not always in line with what could have been expected based on the schools' educational concepts. Most conspicuously, in the innovative schools it was mainly the teacher who operated the IWB.

One characteristic that all four schools in this study had in common was the fact that the IWB was almost exclusively used in whole-class lessons. This confirms the findings from other studies that the IWB appears to reinforce whole-class teaching. However,
our findings contradict the suggestion by for example Moss, Carrey, Levacic, Armstrong, Cardini, & Castle (2007) that use of the IWB also leads to more transmission-style teaching and that it reduces the classroom interactivity to the direct interaction with the IWB. Both the innovative schools and the traditional schools in our study provide examples of the IWB being used to support whole-class teaching in which students had an active role in controlling the content on the IWB and/or in the dialogue. The diversity of interactivity patterns in traditional schools and the occurrence of some innovative episodes in these schools, may even indicate that the IWB facilitates a transition to a more active role for students in the teaching-learning process. Distinguishing the aspects operation of the IWB, control of IWB content and dialogue in the analysis of interactivity has proven useful in this study; it has provided us with a detailed and nuanced picture of what goes on in traditional and innovative schools when the IWB is used. Our findings thus contribute to insight into the variety of ways the IWB is and can be used in educational practices. They also underline that interactivity of IWB use should not be judged on the basis of who operates the board alone. An active role for students in operating the board can go hand in hand with teacher-dominated transmission-style teaching. This has clear implications for educational practice. When developing learning arrangements with the IWB it is important to be aware of these different aspects of interactivity; this awareness can help teachers to make conscious decisions about the type of interactions they intend to invoke. Notwithstanding the nuances, a relation between the school’s educational concept and the IWB-supported interactivity in whole-class lessons was found. The situations described in this study can therefore serve as examples for educators who want to develop IWB use in a concept-guided way. Our finding that teachers do indeed develop IWB-supported lessons with types of interactivity that fit the educational concept of their school can furthermore promote realistic expectations with regard to the impact that the IWB has on classroom practice in a particular school type. The fact that the most prominent interactivity patterns within each school type occurred in all grades represented in the study suggests that the differences in interactivity patterns found between the school types are unlikely to be explained by student age alone. For future research into the relationship between educational concepts and
patterns of interactivity, however, we suggest a more even distribution of grade levels across the school types in order to rule out the possibility that the found patterns are related to student age rather than educational concept. A larger sample and a more evenly distributed representation of both science and arts lessons would also improve generalisability of these findings and deepen our understanding of the patterns and relations that were found.
Part II  Integration of the developed ICT use
Introduction

An increasing body of studies indicates that digital technology has the potential to improve learning processes (cf. Archer, Savage, Sanghera-Sidhu, Wood, Gottardo, & Chen, 2014; Cheung & Slavin, 2012; Cheung & Slavin, 2013; Lemke, Coughlin, & Reifsneider, 2009). Well integrated use of technology in classroom practice is therefore by many considered desirable and is being advocated by many national governments (cf. Lewin & McNichol, 2015). In the literature a considerable amount of attention is paid to factors that either impede or promote adoption and integration of technology. The fit between the proposed technology use and the school’s educational concept is considered to be one of the factors that promote the integration of technology (Zhao, Pugh, Sheldon, & Byers, 2002; Niederhauser & Stoddart, 2001). Concept-guided development of technology, in which school teams develop and implement forms of technology use in line with the school’s educational concept, is a pedagogy-driven approach that aims to promote this fit and is therefore expected to promote the integration of technology that can enhance learning. Previous studies (de Koster, Kuiper, & Volman, 2012; de Koster, Volman, & Kuiper, 2013) have shown that schools with either a ‘traditional’ or an ‘innovative’ educational concept that developed their use of technology in a concept-guided way, realised clearly distinguishable types of technology use, aimed at supporting various types of teaching and learning. One of these previous studies (de Koster, Kuiper, & Volman, 2012) suggested there were

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differences in the ease with which the developed technology use could be integrated into the classroom. In this present study we investigated how the integration of the developed technology use into the different school types’ classroom practices can be characterised in quantitative and qualitative terms.

**Background**

Over the past 25 years a body of literature has developed that focuses on the integration of technology in education. In this literature we find a shift from a strong focus on the technology and its opportunities for teaching and learning to a focus on pedagogical desirabilities and the ways in which certain technologies can support these (Ertmer & Ottenbreit-Leftwich, 2013; Kampylis et al., 2013; Lewin & McNichol, 2015; Mor & Mogilevsky, 2013). This study clearly has the latter focus, being concerned with the integration of technology that has been identified by the teachers involved as providing a possible support for the teaching and learning that they aim for.

**Promoting the integration of technology in educational practice**

From the literature a number of conditions that promote successful integration of technology becomes apparent. A condition that is receiving growing attention is the fit between technology use and the educational concept underpinning these practices. Zhao, Pugh, Sheldon and Byers (2002) describe this in terms of the distance between the technology innovation (i.e. the intended development of the school’s use of technology) on the one hand, and the school’s educational culture and practice on the other hand. The shorter this distance, the better chances are for successful technology integration. This is consistent with findings indicating that how and with what learning effects technology resources are used, depends on how well they fit in with the established patterns of activity (Tolmie, 2001). Similarly, Niederhauser and Stoddart (2001) found that teachers are inclined to apply technology in a manner that is consistent with their personal perspectives about curriculum and instructional practice. This all seems to imply that if use of technology is developed to fit the school’s
educational concept, the chances of the technology becoming integrated into the school’s classroom practices are increased. Consistent with these findings a concept-guided approach to developing technology use has been proposed as a way to help schools integrate technology into their teaching and learning, where and when appropriate, by taking the school’s educational concept as the main starting point for developing its technology use (de Koster, Kuiper, & Volman, 2012).

Defining technology integration

Reviews of the literature on technology integration indicate that there is no unequivocal interpretation of the term technology integration (e.g. Hew & Brush, 2007; Vanderlinde, 2011). An often used indicator for technology integration is the quantity of use, like the number of computers available to students or the frequency with which technology is used, generally associating higher frequencies of use with higher levels of integration (e.g. Mueller, Wood, Willoughby, Ross & Specht, 2008; Tondeur, Hermans, van Braak & Valcke, 2008). Yet caution is due, as a comprehensive comparative PISA study (OECD, 2015) shows that although moderate frequencies of computer use at school can improve learning outcomes, very high frequencies of use appear to lead to considerably lower learning outcomes. So a high frequency of technology use in itself is not what schools should strive for. On the other hand we find studies that focus instead on the pedagogies that are being supported with technology. Many of these studies imply that technology can only be considered ‘integrated’ when it supports a specific type of teaching and learning. One example is the frequently cited five stage model of Sandholtz, Ringstaff and Dwyer (1997), which suggests that the highest stage of technology integration is only found in a context of innovative, constructivist teaching and learning (Mueller et al., 2008). Likewise Lim (2007) characterises effective technology integration in terms of teachers using technology to develop students’ thinking skills. In these studies the ultimate goal of integrating technology seems to be a use of technology that supports one specific type of pedagogy. A concept-guided approach to development of technology use however calls for a more neutral qualitative definition that gives room to a variety of pedagogies (‘educational concepts’) that can
be supported by integrated technology use. We propose that when taking a concept-guided approach our definition of technology integration should encompass the perceptions of the teachers who carry out these pedagogies in their everyday classroom practices. The question whether technology is successfully integrated into a school’s classroom practice thus translates into: do the teachers involved perceive the technology as having become an integral part of their practices?

This study

This study was performed in the context of a project in which five primary schools in the Netherlands developed technology-enhanced learning arrangements in a concept-guided way in the course of two school years (de Koster, Kuiper, & Volman, 2012). The schools participating in this project had an educational concept that was either labelled as ‘traditional’, which refers to a fixed curriculum and a strongly teacher-directed approach, or as ‘innovative’, indicating a more open curriculum and a student-centred approach. At each school a team of teachers was supported in designing and implementing up to four technology-supported learning arrangements of their own choosing. As the quantity of technology use is widely used and accepted as an indicator of technology integration we deemed it appropriate to include this aspect of integration in our study. Yet, befitting the concept-guided approach and the role of the teacher as the ‘embodiment’ of the school concept in the classroom, we propose to add to this the teacher’s perspective: How do the teachers who work with the technology appreciate it as a tool in their classroom practice? From this viewpoint the level of technology integration that can be achieved does not by definition depend on the school’s educational concept, as is suggested by the five stage model of Sandholtz, Ringstaff and Dwyer (1997) and similar theories, but rather depends on how well the technology use fits into the classroom practice. However, a previous study (de Koster, Kuiper, & Volman, 2012) did show that the ‘traditional’ schools developed less complex use of technology that was more easily implemented, while the ‘innovative’ schools designed rather complex use of technology, which seemed to hinder its implementation. These findings suggest that concept-guided development of technology use might lead to
concept-specific differences in the achieved levels of technology integration, possibly both in quantitative and in qualitative terms. This suggestion led to the main research question for this study:

*How can the achieved integration of technology in ‘traditional’ and ‘innovative’ schools that develop their use of technology in a concept-guided way be characterised in quantitative and qualitative terms?*

In order to answer this main question we formulated the following sub questions:

1. How can the achieved technology integration in these schools be characterised in quantitative terms?
2. How can the achieved technology integration in these schools be characterised in qualitative terms?
3. What differences can be found between the school types with regard to the quantitative and qualitative characteristics of technology integration?

**Method**

*Context of this study*

The study was conducted in the context of a project of concept-guided development of technology use in the Netherlands in which five primary schools participated. During the project a team of teachers at each school designed, developed and realised up to four technology-enhanced learning arrangements over the course of two school years. A learning arrangement would consist of a lesson plan, including learning goals, tools and activities, and could concern any school subject. Learning arrangements could entail anything from the use of ‘drill-and-practice’ software to the use of a wide range of technological tools to support a variety of learning activities in an enquiry-based project. Teachers participated on a voluntary basis and were given limited compensation of the time they invested in the project. The teachers were coached by educational counsellors from an external organisation. The educational counsellors helped the teachers reflect on their school’s educational concept and their school’s ambitions for
intensifying its use of technology in line with this concept. Based on this reflection the learning arrangements were designed as the teachers saw best fit. This procedure was expected to promote the fit between the school’s concept and the resulting use of technology. The teacher-as-designer approach, with an active, voluntary role for the participating teachers, was expected to favourably affect the implementation and integration of the designed learning arrangements by installing a sense of ownership in the teachers (Handelzalts, 2009; Maher, 1987). The researchers were not involved in the development of the learning arrangements.

Participants and setting

The five primary schools in this study were labelled as either ‘traditional’ (indicated as the Princess Amalia School and the Alma Mater School) or ‘innovative’ (indicated as the Beehive School, the Queen Beatrix School and the Beech Grove School). These labels were based on a general impression of the schools, extracted from interviews with stakeholders at each school at the start of the project, and verified by the researchers during the first year of the project. The teaching and learning practices at all participating schools met the standards of the Dutch Inspectorate of Education. At each school two or more teachers participated over a period of two school years. The grade levels of their classes varied from second to sixth grade.

In the ‘traditional’ schools educational goals are largely pursued through the use of teaching and learning materials with a more or less fixed content. Most instruction is given as direct whole-class instruction. After instruction, pupils mostly work individually or in pairs on assignments or exercises directly linked to the textbook content and remedial instruction is given in smaller groups, informed by test results. The three ‘innovative’ schools in this study intend to make learning attractive and engaging for pupils, for instance by giving them more control over their learning process and by using inquiry learning activities. Science and social sciences are taught in multidisciplinary projects revolving around a certain theme. Subject matter is partly, in one school mainly, taught in the form of workshops. Classes are multi-aged, in order to give pupils the opportunity to learn with and from each other. Standard teaching and
Instruments and data collection

For this multiple case study (Yin, 2009) we operationalised technology integration both in quantitative and in qualitative terms. The quantitative character of the achieved technology integration (sub question 1) was captured through summarizing the number or different tools that were used in the learning arrangements and how many computers were available per class, based on data from embedded case studies (Yin, 2009) of each learning arrangement that was carried out. We obtained these data through classroom observations (mostly videotaped), individual interviews with teachers, and logs and registration forms filled in by teachers and pupils during the realisation of the learning arrangements. The data were gathered by two teams of researchers from different research institutes, one team investigating two schools, the other three. The descriptions of the learning arrangements based on the collected data were verified by the teachers involved. For the qualitative character of the achieved technology integration (sub question 2) we looked at how the teachers themselves perceived and valued the developed technology use in their schools. This was determined through analysis of semi-structured focus group interviews from an overall study of the project. The focus group interviews were held with the involved teams of teachers at each school, at the beginning of the first year (before the learning arrangements were realised, interview 1), at the end of the first year (one or two learning arrangements realised, interview 2), and at the end of the second year (all learning arrangements realised, interview 3). The focus groups at each school consisted of two to eight teachers who participated in the development and/or the realisation of one or more learning arrangements. As shown in Table 1 the composition of the focus groups varied somewhat across the study, as not all teachers were able to participate in each interview. For the second interview at the Alma Mater School only one teacher was available and the teachers at the Beech Grove School did not participate in the third round of interviews because the school left the project in the course of the second year (see also 3.2.5).
Table 1. Composition of focus groups per school and per interview

<table>
<thead>
<tr>
<th></th>
<th>Princess Amalia School</th>
<th>Alma Mater School</th>
<th>Beehive School</th>
<th>Queen Beatrix School</th>
<th>Beech Grove School</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interview 1</strong></td>
<td>T1, T2</td>
<td>T1, T2, T3</td>
<td>T1, T2</td>
<td>T1, T2, T3, T4, T5</td>
<td>T1, T2, T3</td>
</tr>
<tr>
<td><strong>Interview 2</strong></td>
<td>T1, T2</td>
<td>T2</td>
<td>T2, T3</td>
<td>T1, T2, T3, T4, T5</td>
<td>T2, T4, T5, T7, T8</td>
</tr>
<tr>
<td><strong>Interview 3</strong></td>
<td>T1, T3, T4</td>
<td>T2, T4, T5</td>
<td>T1, T4, T5</td>
<td>T1, T9</td>
<td>---</td>
</tr>
</tbody>
</table>

The interview protocol included topics concerning their participation in the project (e.g. ‘what are your experiences with the project so far?’), the technology that was used, and the role it played in the school’s classroom practice, (e.g. ‘to what extent are teaching and learning supported by technology in your school?’). The question what differences can be found between the school types with regard to the quantitative and qualitative technology integration (sub question 3) was answered based on the findings of the first two sub questions, as discussed in 2.4.

**Analysis**

The focus group interviews were transcribed. These transcriptions and the descriptions of the learning arrangements were subjected to both quantitative and qualitative content analysis (Huberman & Miles, 1994; Yin, 2011). In order to find indications of how the achieved integration of technology could be characterised we first selected fragments within the transcripts and the descriptions that contained relevant information on the newly developed technology use. We selected the fragments based on the occurrence of one or more of the following topics:

1. The school’s use of technology related to the developed learning arrangements.
2. The teachers’ account of the role that the developed use of technology played in their classroom practice.
Within the selected fragments we then coded for the following two themes:

A. Descriptions and teachers’ remarks with regard to the tools that were used.
B. Teachers’ remarks on the perceived value of the newly introduced technology, in terms of the technology being perceived as an integral part of their classroom practice.

Within the fragments coded as theme A we then distinguished between the following labels:

a. tools – what was used (how many different tools per learning arrangement)
b. tools – how many computers were available
c. tools – how many technology-enhanced learning arrangements were realised and how many were abandoned during the project

These labels were used for the quantitative characterisation of the technology integration. For theme B we used a grounded theory approach (Glaser & Strauss, 1967; Strauss & Corbin, 1998) to find types of teacher remarks that seemed to indicate that the technology was being perceived as an integral part of their classroom practice. With the labels for theme A (quantities of tools) and the characteristic teacher remarks for theme B (perceived value of technology) we then looked for patterns in the data with regard to these themes. After addressing sub questions 1 and 2 by discussing the patterns that emerged from this analysis, sub question 3 was answered by comparing the patterns across the school types to look for differences that might be attributed to the different educational concepts.

**Results**

The quantitative character of the technology integration at all five schools is presented first in this section. The qualitative results for the teachers’ perspective at the ‘traditional’ and the ‘innovative’ schools are discussed separately. Finally, we compare
the patterns of the teachers’ perspective between the school types. Tables 2 through 6 show what technology was used in each school, in the context of each learning arrangement. The activities or types of activities for which they were used are described in more detail in a previous study (de Koster, Kuiper, & Volman, 2012).

Table 2. Technology use in the learning arrangements at the Princess Amalia School

<table>
<thead>
<tr>
<th>Code</th>
<th>Teacher</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1-1</td>
<td>T1</td>
<td>Individual exercises and tests with mathematics exercise and test software, on desktop computers in the classroom; grade 5 and 6</td>
</tr>
<tr>
<td>A1-2</td>
<td>T2</td>
<td>Interactive classroom instruction on writing and spelling on IWB; some pupils are asked to do an exercise on the IWB; grade 3</td>
</tr>
<tr>
<td>A1-3</td>
<td>T3</td>
<td>Individual exercises and tests with reading comprehension exercise and test software on laptop and desktop computers in the classroom; grade 6</td>
</tr>
<tr>
<td>A1-4</td>
<td>T1</td>
<td>Assignments (on cards) in world orientation, involving web searching, processing and presenting information, in pairs; grade 3</td>
</tr>
</tbody>
</table>

Table 3. Technology use in the learning arrangements at the Alma Mater School

<table>
<thead>
<tr>
<th>Code</th>
<th>Teacher</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2-1</td>
<td>T2</td>
<td>Assignments (on cards) in world orientation: gathering information from an online database on desktop and laptop computers, use of digital photo cameras, individually or in pairs; grade 1 and 2</td>
</tr>
<tr>
<td>A2-2</td>
<td>T3</td>
<td>Mathematics classroom instruction about the metric system on the interactive whiteboard; grade 6</td>
</tr>
<tr>
<td>A2-3</td>
<td>T2, T4</td>
<td>Individual mathematics exercises with mathematics exercise software on desktop computers; grade 2</td>
</tr>
<tr>
<td>A2-4</td>
<td>T4</td>
<td>'Reading' digital picture books, both with whole class (teacher-directed) and independently in small groups and individually; Kindergarten (ages 4-5 years)</td>
</tr>
</tbody>
</table>
Table 4. Technology use in the learning arrangements at the Beehive School

<table>
<thead>
<tr>
<th>Code</th>
<th>Teacher</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1-1</td>
<td>T2</td>
<td>Pupils use digital cameras to make pictures and video clips around a theme, make presentations with their pictures, their video clips and information from the web, and give presentations on the IWB; grades 2 through 4</td>
</tr>
<tr>
<td>B1-2</td>
<td>T1</td>
<td>Pairs of pupils perform a chemical experiment and record and edit a video of the experiment, and show videos on the IWB to the class; grades 4 through 6</td>
</tr>
<tr>
<td>B1-3</td>
<td>T2, T3</td>
<td>Pupils (individual, pairs, small groups) practise multiplication tables through non-digital games connected with multiple intelligences, available in database on school’s digital network; grades 3 through 6</td>
</tr>
<tr>
<td>B1-4</td>
<td>T4</td>
<td>Pupils (pairs, small groups) photograph groups of objects with digital photo cameras. Teacher prints photographs and pupils use photographs to make multiplication booklets; grade 2</td>
</tr>
</tbody>
</table>

Table 5. Technology use in the learning arrangements at the Queen Beatrix School

<table>
<thead>
<tr>
<th>Code</th>
<th>Teacher</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2-1</td>
<td>T2, T5</td>
<td>Pupils (individual, pairs, small groups) report on current events using a variety of tools like digital cameras, pod recorders and presentation software; grades 4/5/6</td>
</tr>
<tr>
<td>B2-2</td>
<td>T4</td>
<td>Teachers give a workshop on the use of several tools. Pupils (individually or in pairs) formulate a research question related to the theme 'our house', carry out a small research project using a variety of tools (internet, digital microscope) and present their results to the class on IWB or on wall posters; grades 4 through 6</td>
</tr>
<tr>
<td>B2-3</td>
<td>T1, T9</td>
<td>Teachers give a workshop on web searching. Pupils (individually or in pairs) formulate a research question related to the theme 'the Caribbean' and carry out a small research project, mainly on the web, and present their results to the class on IWB or on wall posters; grades 4/5/6</td>
</tr>
</tbody>
</table>
Table 6. Technology use in the learning arrangements at the Beech Grove School

<table>
<thead>
<tr>
<th>Code</th>
<th>Teacher</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B3-1</td>
<td>T1</td>
<td>Pupils (individually or in pairs) formulate a research question on a social science subject and carry out a small research project using a variety of tools, like the internet, digital microscopes and topographical software; grades 1/2/3</td>
</tr>
<tr>
<td>B3-2</td>
<td>T2, T3</td>
<td>Teachers give a workshop on multiple intelligences and give pro-active guidance on the use of connected to multiple intelligences while pupils (individually or in pairs) formulate a research question on a subject of their choice and carry out a small research project with the use of the internet, digital microscopes, topographical software, laptop computers and the IWB; grades 1/2/3</td>
</tr>
</tbody>
</table>

At each school four learning arrangements were designed. The teachers at the ‘traditional’ schools developed relatively simple, transparent learning arrangements with one or two tools per arrangement and a varying intensity of technology use. At these schools all four learning arrangements were initially realised as planned. At the Princess Amalia School one learning arrangement was partly abandoned before the end of the project (the testing software in A1-1) and one was altered (the interactive use of the IWB in A1-2). The teachers’ reflections on this are discussed in 3.2. The teachers at the three ‘innovative’ schools developed quite complex technology-supported learning arrangements, using a great variety of technology tools. The complexity of the learning arrangements presented the teachers at these schools with considerable logistical and technical challenges. At the Queen Beatrix School and the Beech Grove school this was one of the reasons why not all learning arrangements were realised. At the Beehive School all four learning arrangements were realised as planned, yet one was abandoned before the end of the project (B1-3).

Quantities of tools

No significant differences were found between the ‘traditional’ and the ‘innovative’ schools in terms of the total number of different tools that were used. In all five schools a combination of desktop and/or laptop computers and IWBs was used in most learning
arrangements. By the end of the project the IWB had replaced the traditional chalkboard in the participating classes in all five schools. In addition to these tools the ‘traditional’ schools used exercise and/or testing software in two out of four learning arrangements. Both ‘traditional’ schools used a total of seven tools (hardware and software) across the learning arrangements. At the ‘innovative’ schools the use of computers and the IWB was combined with the use of audiovisual tools and digital microscopes. At two of these schools a total of eight different tools was used, while at one school six different tools were used. However, when we look at the number of tools that were used within one learning arrangement, we find that at the ‘traditional’ schools only one to three different tools were used per learning arrangement (as can be seen in Tables 2 and 3), while at the ‘innovative’ schools most learning arrangements were supported by three or more tools (Tables 4, 5 and 6). The numbers of computers per class (desktop and laptop) did differ between the schools, but not between the school types, as shown in Table 7.

**Table 7. Number of computers per class per school**

<table>
<thead>
<tr>
<th>School</th>
<th># Desktop computers per class</th>
<th># Desktop computers shared</th>
<th># Laptop computers per class</th>
<th># Laptop computers shared</th>
<th># Classes sharing computers</th>
<th>*Av. # computers per class</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traditional</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Princess Amalia School</td>
<td>4</td>
<td>8</td>
<td>3</td>
<td>6.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alma Mater School</td>
<td>2</td>
<td>35</td>
<td>4</td>
<td>10.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Innovative</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beehive School</td>
<td>4</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queen Beatrix School</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>5</td>
<td>7.2</td>
<td></td>
</tr>
<tr>
<td>Beech Grove School</td>
<td>4</td>
<td>9</td>
<td>3</td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Average number of computers per class, both desktop and laptop, based on number of computers and number of classes sharing computers
In three schools (one ‘traditional’ and two ‘innovative’) there were four desktop computers per classroom and at one of the ‘innovative’ schools there were also six shared desktop computers. In one ‘traditional’ school there were two desktop computers per classroom, and in one ‘innovative’ school most classes had none, yet at these schools there were more laptops per class. The laptops were shared among a number of classes in four out of five schools. So apart from the number of different tools per learning arrangement no clear distinctions could be found between the school types in quantitative terms.

**Integration of technology at the ‘traditional’ schools – the teachers’ perspective**

*Princess Amalia School*

According to the teachers at the Princess Amalia School the laptop computers soon became integrated into classroom practice of the participating classes during the first project year. The exercise software for mathematics (A1-1) and the exercise and test software for reading comprehension (A1-3) were also soon used routinely in all upper grades.

Int. 2  T1: It has become a logical whole. It soon became something logical. […] It became a self-evident use.

In general the convenience of the increased possibilities of the textbook-supporting software was mentioned as an important aspect several times by the teachers.

Int. 3  T3: I’ve mainly been doing the comprehensive reading [software]. That was just positive. That’s just going well. And yeah, it didn’t give me a lot of extra work, it feels like.
T1: Yes, I’m really happy with comprehensive reading on the computer too. I think that’s a real enrichment. Especially those [assignment] cards.

The mathematics testing software however (A1-1) was perceived as poorly usable and was therefore abandoned. During the implementation of the fourth learning arrangement (A1-4), the use of the available computers was intensified because of the focus on student use of the internet and presentation software in this learning arrangement. This may explain why by the end of the project the number of available computers was perceived by the teachers as insufficient even though at the end of the first year they had perceived the number of computers to be sufficient.

Int. 3  T2: […] we still don’t have enough computers. […] They need a lot of computers to search for information, to type in Word, to make a Powerpoint slideshow.
T4: So, yeah, for science and social science you couldn’t really do without.
T2: You really can’t.

The teachers seemed to unanimously perceive a wide availability of computers as indispensable for their classroom practice. The fact that by the end of the project the IWB had completely replaced the blackboard in the school shows that this tool was integrated as well. Nevertheless few explicitly positive comments about the IWB were made by the teachers during the focus group interviews. By the end of the project the board was still used in language lessons (A1-2), but in a less interactive way.

Int. 3  T1: At the start when I did that learning arrangement with spelling I made my own lessons [for the IWB]. But when can you do that? […] You scan your lesson and you do something with the board. But not all that’s possible.
Int: And that’s a matter of time?
T1: Yes. We have very little time.
The first learning arrangement at this school (A2-1) contained only a limited amount of technology use, restricted to laptops (e.g. for searching information in an information database) and infrequent use of the digital camera. This was due to the limited use of technology that was prescribed by the learning materials for this learning arrangement (i.e. the assignment cards, see Table 3. Also in the third learning arrangement (A2-3) technology use was limited. Here the software exercises from the math program replaced only the complementary (program-independent) online exercises that the pupils did previously. The teacher did not make use of the available options for differentiation in the software, because of the limited time for getting acquainted with the software and limited technical support. The IWB on the other hand was used regularly, replacing the chalkboard completely. The teachers gave several examples of ways in which the IWB was used ad hoc during instruction lessons to support the introduction of new concepts.

Int. 1 T3: Almost every day there is something of which we all say: ‘how exactly does that work?’ and we want to know more about it and you can show it right away [using the internet and IWB].

Int. 2 T2: [The IWB] is simply being used in the school. Yes. Daily. It is just in replacement of the chalkboard. It’s not like: right, now we’re going to do something with the IWB. That’s not what it’s like.

Grades 1 and 2 (combined in one class) received an additional fifteen laptops. By the end of the first year of the project, the teacher of this class indicated a strong increase in the computer use by her pupils, mainly on four laptops that were constantly available for the pupils in her classroom, ready to use. She was very enthusiastic about the increased possibilities for the students on the laptops.
Back then five minutes just wasn’t enough. You’d have to find a laptop, that was working, or didn’t have an empty battery. [...] And now we have it all ready at hand. And therefore they’re working on the laptops a lot more. And therefore they can do a lot more with them. I can use every five minutes. If they have nothing else to do, they can just sit down and do math or language or figure out something to do.

At this school as well, the teachers were very positive about the conveniences of the software that was linked to the learning materials that were used. The software to a large extent replaces the paper materials that were used before.

Now I’ve got it all digitally. [...] Before, I’d look up in the [teacher’s] manual what I’d have to do. But now it has everything, per day [it says] what we have to do that day. Also the worksheets, you know, the examples. Yes, everything is in it.

Integration of technology at the ‘innovative’ schools – teachers’ perspective

Beehive School

The first two learning arrangements at the Beehive School included the use of the IWB, both by the teachers and the pupils. The teachers initially also gave examples of using the IWB for activities outside the learning arrangements.

I wouldn’t want to miss [the IWB] anymore.

It’s ideal. For example after the school holidays: ‘Where have you been on vacation?’ And then you google and search and you can fly across those mountains and ‘wow, here’s a lake’ and yes, that’s really cool. And educating.
Remarkably however, by the end of the second project year, the interviewed teachers at the Beehive School indicated that their appreciation and use of the IWB gradually decreased, although they did not abandon its use altogether. The laptop computers turned out to be more important to their teaching and learning than the IWB.

Int. 3  T4: We don’t have an IWB. But we will get one. Although we didn’t really miss it that much this year. Because if we wanted to do something we’d ask if we could use your board or something.
T1: For me that’s not the first thing that I would miss if it wasn’t there either. I think it’s very useful, I do see its added value, but actually I find the laptops far more important than the IWB.

In general the technology was perceived as obvious and indispensable. The tools had become ‘one of the materials’.

Int. 2  T2: I wouldn’t say it has become second nature to us, but it has become a normal learning material, just like the books you use, or whatever. Material. It’s just one of the materials. [Before] I would really have to think ‘how can I use film or visual material, or sound on MP3 players?’ I would really have to think hard to come up with something. From nothing, like. Yeah, and now I feel that I have a foundation on which I can build.

Int. 3  T1: I couldn’t do without anymore. [...]
T4: I agree.
T1: But I also think it’s important for [the pupils] to use other sources as well.

With this and other remarks the teachers stressed that they find the use of technology in the classroom very important, while at the same time indicating that this importance is relative and analogue materials should be used as well, i.e. technology should be complementary to the traditional materials.
Queen Beatrix School

After designing the learning arrangements the teachers at the Queen Beatrix School initially expressed some fears of not being able to embed the new technology use in their everyday practice.

Int. 1  
T1: [...] When we started this project we had [the idea] that we could use the new tools in our classrooms and now it has come down to two separate workshops [outside of the classrooms]. Those are really cool and our ideas are in them but we haven’t discussed what we can do with [the tools] in our classrooms.
T3: A workshop is great but it’s something extra.
T1: It’s not your foundation.

After the first project year however, they made many remarks indicating their perception of the new tools as obvious and indispensable, both in the workshops and in the classroom.

Int. 2  
T4: And now I can hardly imagine what we’d do without the cameras. [...] [the computer] is on…
T2: Yeah, that thing is on 24/7 almost.

Int. 3  
T1: Yes, really a lot. A lot of things that you’re not really aware of. [...] It’s automatic, and then afterwards you [T9] say: but you also did this and that…

By the end of the third and final learning arrangement the time investment in the project did not feel like something extra anymore. It had fully replaced the way these projects had been carried out before the start of the project, when much less technology was used.
T9: [At the beginning of the project] there was simply not enough time. The children would come up to you and say: how does this [tool] work, how does that work? And if you as a teacher didn’t know then we just wouldn’t do it. […]

T1: Yeah, and also because it was something extra, like. Last year. Then that takes an effort in itself. And then in addition you’d have to figure out stuff, that turns out to be quite complicated. And this year it’s just a lot better, because it’s not something extra but it’s deepening something that you were already doing.

The IWB was used daily for presentations by pupils and for drawing mind maps, in addition to the planned and/or ad hoc illustration of topics during whole-class instruction by using the internet.

T6: […] this afternoon we were doing experiments about fireworks and how it is made. Normally you’d search and fiddle for a long time and now you have a student look up the [recent] fireworks disaster on the computer. Before, ... well, you could order a video tape and it would take six weeks and it wouldn’t be meaningful for the kids. Now it’s very easy to ad hoc react to stuff that’s important for students. I find that a great advantage of this board.

T9: the other day we read a story about forest fires in comprehensive reading. Then you can immediately switch to the news, because there were forest fires in Australia. Then you can show yesterday’s news bulletin.

_Beech Grove School_

The technology use that was developed at the Beech Grove School was highly appreciated by the teachers. Several comments were made on the value of the IWB and the computers.
T1: At one point, just from the top of my head, I gave a lesson about the antiquity. [...] Just looked [it] up and talked about it. [...] I asked: what do you know about this? And a lot of stories came out. That’s just so meaningful. You just don’t get that in an ordinary history lesson.

T5: We had only two [computers] or so. [...] So you’d have to make the decision for yourself all the time: which child needs it the most at this moment? And that’s really hard. Because one uses it for spelling, the other for his research questions. And they all need it badly. So this is great, that it’s possible.

T2: At some point [the counsellor supporting the teachers] mentioned how much she enjoyed constantly seeing children working on the computers. Instead of being allowed a certain amount of time. They’re always in use.

The teachers also gave many examples of activities that have been made possible or a lot easier and more accessible by the use of technology, like writing on the computer instead of on paper, indicating that the technological tools are to an extent replacing the traditional means rather than complementing them.

T5: If you just look at the children that have difficulties writing. And write much longer texts on the computer than if they had to do it by hand. Or that they can add an image, which makes it fun of course. While before… [...] There’s so much more in it than in [the textbooks].

**Similarities and differences between the school types – the teachers’ perspective**

In this section we summarise the similarities and differences that were found in the teachers’ perception of the developed use of technology. We found the following types of remarks that seemed to indicate that the technology was perceived as an integral part of the teachers’ practice: technology perceived as common, matter-of-factly; technology perceived as indispensable; technology perceived as either replacing or complementing
the traditional tools. The following comparison between the school types was based on these characteristics of the teachers’ remarks. The quotes that are used to illustrate these similarities and differences are taken from the quotes presented above.

**Technology perceived as common**

At all five schools teachers’ comments showed they perceived most of their new technology use as common or obvious. This is reflected in phrases like ‘You’re not aware of that anymore because it’s so easy’ (Princess Amalia School, T4), ‘[The IWB] is simply being used’ (Alma Mater School, T2), ‘It’s just one of the materials’ (Beehive School, T2), and ‘A lot of things that you’re not aware of, it’s automatic’ (Queen Beatrix School, T1).

**Technology perceived as indispensable**

Similarly, at all five schools the teachers expressed perceiving their new technology use as indispensable, as reflected in phrases like ‘You couldn’t really do without’ (Princess Amalia School, T4), ‘I couldn’t do without anymore’ (Beehive School, T1), ‘I can hardly imagine what we’d do without the cameras’ (Queen Beatrix School, T4), and ‘[the pupils] all need it badly’ (Beech Grove School, T5). At one ‘traditional’ school one tool (math software) was abandoned because it did not function as expected. At one ‘innovative’ school on the other hand, one learning arrangement was ‘suspended’ because the ELE for which it was designed was not realised yet, which may have indicated implicitly that the ELE was perceived as indispensable even before it existed.

**Technology perceived as replacing and/or complementary**

With regard to the technology being perceived by the teachers as replacing and/or complementing the materials that were used previously a slightly more varied picture was found. In all five schools by the end of the project the IWB had replaced the
traditional chalkboard. It was highly valued for its multimodal possibilities, and especially the added value of visualizing lesson content on the IWB was mentioned frequently by teachers from both school types. The software used by the ‘traditional’ schools did both complement and replace the traditional materials, as computer exercises were combined with paper exercises and some paper tests were replaced completely by digital tests. At one of the ‘innovative’ schools the teachers agreed that the value of the technological tools is relative, as ‘it’s important for [the pupils] to use other sources as well’ (Beehive School, T1). At the other ‘innovative’ schools the enthusiasm about the value of technology seemed less conditional. At the end of the project the teachers at one of these schools agreed that the new use of technology was ‘not something extra’ anymore (Queen Beatrix School, T1) and at the other school the added possibilities of the tools were stressed, comparing ‘before’ (i.e. working on paper and in textbooks) with ‘now’ (working on the computer).

Conclusion

In this study five schools with either a ‘traditional’ or an ‘innovative’ school concept were studied as they participated in a two-year project of concept-guided development of instructional use of technology. We explored how the achieved integration of technology in two ‘traditional’ and three ‘innovative’ elementary schools that developed their use of technology in a concept-guided way could be characterised in quantitative and qualitative terms. We studied the technology-rich learning arrangements that were developed in this project (embedded case studies) and how the teachers perceived their newly developed technology use (focus group interviews), and we compared the emerging patterns between the school types.

Quantitative character of technology integration compared

The quantitative character of the integrated technology was measured through summarizing the number of different tools that were used in the learning arrangements and how many computers were available per class. When looking at the number of
different tools that were used we found that the ‘traditional’ schools tended to use less tools per learning arrangement than the ‘innovative’ schools. The numbers of computers per class (desktop and laptop) did differ between the schools, but not between the school types. Three schools (one ‘traditional’ and two ‘innovative’ schools) had an average of around seven computers per class, while at one ‘traditional’ and one ‘innovative’ school each class had around ten computers at its disposal. In one ‘traditional’ school one learning arrangement was partly abandoned before the end of the project and one was continued in a ‘toned-down’ fashion. At one ‘innovative’ school one learning arrangement was abandoned (suspended) before the end of the project.

Qualitative characterisation compared

The qualitative character of the integrated technology was measured through the value of the technology as perceived by the teachers. With respect to the labels ‘technology perceived as common’ and ‘technology perceived as indispensable’ no differences were found between the school types. At all five schools the technology that was used in the learning arrangements that were continued was in general perceived as common or ‘automatic’ and most of it also as indispensable. Both with regard to specific tools, like the IWB, and to technology in general teachers from both school types expressed that they ‘could not do without’ anymore, indicating that at least some of the tools and their applications were highly valued by these teachers. In all five schools some of the newly introduced technology replaced the non-digital materials while other tools merely complemented the existing materials or tools. All schools replaced the chalkboard with IWBs in all participating classes. The software used by the ‘traditional’ schools did both complement and replace the traditional materials. At the ‘innovative’ schools a slight within-group difference was seen between the schools. At one school the value of the new tools was explicitly put into perspective, the IWB being considered less important than the laptops and more stress being put on the complementary value of technology, while at the other two schools the tools seemed to be valued more unconditionally and more stress was put on technology replacing ‘the old’.
Discussion

Our findings suggest that a concept-guided development of technology use does promote the integration of the technology use that supports different pedagogies when defining technology integration in a qualitative way. This supports earlier findings that minimizing the distance between technology innovation and the school’s educational practice promotes technology integration (Zhao, Pugh, Sheldon, & Byers, 2002). We also conclude that the integration of technology at schools with different school concepts does not necessarily differ, which stands in contrast to the suggestion that the highest stage of technology integration is only found in a context of innovative, constructivist teaching and learning (Sandholtz, Ringstaff, & Dwyer, 1997; Mueller et al., 2008). To what extent exactly the achieved level of integration can be attributed to the concept-guided approach cannot be concluded from this exploratory study. More research is needed to investigate how and under which conditions concept-guided development of technology use promotes technology integration. Other factors are likely to have contributed to the achieved level of integration as well, like the teachers’ views and beliefs about technology at the outset of the project, their general attitude toward innovation, possible tensions within the teams of teachers-as-designers, the role of the counselors and school leaders and the support and resources that were provided. Further research is needed to gain more insight into these factors.

The data also suggest that what exactly is valued in the tools and applications that are used quite surprisingly does not vary greatly among the schools. Especially with regard to the IWB the teachers’ responses seemed to indicate that the multimodality of this tool and its possibilities for visualizing subject matter is valued equally in both school types. On the other hand, the interactive possibilities of the tool in terms of giving pupils more control over what happens on the board were not mentioned at any of the schools in the focus group interviews, even though in both school types we did observe this type of interactivity taking place (de Koster, Volman, & Kuiper, 2013). Did the teachers not value this affordance of the IWB as much as is generally expected, or were they simply not aware of their appreciation, taking it for granted already? Similarly, the fact that at one of the ‘innovative’ schools by the end of the project the teachers realised they
valued the laptop computers more than the IWB might be seen on the one hand as a failed integration of the IWB or on the other hand as a gradual articulation of the teachers’ ideas about their needs with regard to technology. Taking the affordances of technology for granted and developing more articulated ideas about technology in the classroom might be seen as additional signs that technology is becoming integrated in the teachers’ thinking and practice and thus need to be added to our conceptual framework for technology integration. These findings underscore the importance of the teachers’ perception of their technology use as a major indicator of technology integration and as a factor to be reckoned with when supporting a school in developing its technology use. More systematic reflection with teachers on their technology use can further enhance and inform the assessment of the level of technology integration, both for research purposes and for those involved in the actual development of technology use.

Finally, in this study we focused on the extent to which the teachers involved in this project succeeded in integrating technology into their classroom practices. The quality and outcomes of the teaching and learning, both before and after the integration of technology, were beyond the scope of this study, but obviously deserve equal attention. Further studies will therefore also have to focus on the extent to which the integrated technology use actually helps to improve these practices.
Chapter 5  Sustainability of technology integration in the classroom in a ‘traditional’ and an ‘innovative’ school

Introduction

There is increasing evidence that digital technology (in this study referred to as ‘technology’) has the potential to improve learning processes and outcomes (cf. Archer, Savage, Sanghera-Sidhu, Wood, Gottardo, & Chen, 2014; Cheung & Slavin, 2013; Lemke, Coughlin, & Reifsneider, 2009; Lewin & McNichol, 2015; Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011). Yet for technology to have such a positive impact on learning processes it needs to be sustained over a longer period of time (Jerald, 2005). In general, a development, change or innovation in education is not considered sustainably integrated until it remains clearly visible in the school (Datnow, 2005) and is perceived as a part of the teachers’ own values (McLauugin & Mitra, 2001). Sustainable change in schools also means an extension of the innovation to ‘next generation improvements’ and adaptation to the school’s changing needs and possibilities (Jerald, 2005). This study focused the sustainability of technology integration in a ‘traditional’ and an ‘innovative’ school involved in a project in which teachers developed and implemented technology-rich learning environments in a concept-guided way and on how differences the schools might be explained.

Theoretical background

In order for innovations in education to lead to the intended effects they need to be sustained over a longer period of time (Jerald, 2005). The sustainability of technology innovations in schools has been studied from different angles. One aspect of

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5 de Koster, S., Volman, M., & Kuiper, E. (in revision). Sustainability of technology integration in the classroom in a ‘traditional’ and an ‘innovative’ school.
sustainability of an innovation that has received attention in the literature on educational innovations is longevity, i.e. the extent to which an innovation lasts over time (Datnow, 2005). Longevity depends on, among other things, the loyalty of those involved in the innovation, especially after the support that is usually given in the implementation phase is no longer available (e.g. Han & Weiss, 2005; Wagner, Day, James, Kozma, Miller, & Unwin, 2005). Sustaining an innovation however, takes more than just maintaining it beyond the implementation phase. In order to be sustainable, a change also needs to be extended to ‘next generation improvements’ and, over time, to be adapted to the school’s changing needs and possibilities (Jerald, 2005). This ‘fine-tuning’ of reform elements is needed ‘to ensure that they keep working as the environment around them changes’ (Jerald, 2005; p. 4).

Promoting sustainable technology integration

Innovations in education do not in and of themselves endure or become institutionalised (e.g. Fullan, 2000; Hargreaves & Fink, 2004; Owston, 2007; Vanderlinde, Aesaert, & van Braak, 2014). Central to many perspectives on sustainable change in education is the cultural character of teaching practices. Gallimore and Ermeling (2012) for instance suggest that for teaching to be sustainably changed the existing routines, settings, and activities need to be addressed, i.e. changed. From a slightly different perspective, and focusing specifically on the integration of new technologies, Zhao, Pugh, Sheldon and Byers (2002) found in their research that technology integration is promoted by a minimal distance between the intended development of the school’s technology use and the school’s educational culture and practice. This finding suggests that schools have a choice to either change their culture and practice to fit the intended technology-enhanced teaching and learning – as Gallimore and Ermeling (2012) suggest –, or the other way around: to adapt their plans for technology-enhancement to fit the cultural reality into which they will be implemented. Another body of research argues that technology-integration efforts need to start from pedagogical needs rather than technological possibilities (Ertmer & Ottenbreit-Leftwich, 2013; Kampylis et al., 2013; Lewin & McNichol, 2015; Mor & Mogilevsky, 2013; Kirkwood & Price, 2005; Ten
Brummelhuis & Kuiper, 2005). In line with these arguments for an alignment of technology use with the school’s educational concept as cultural context we propose a concept-guided approach to the development of technology use. Central to this approach to enhancement of teaching and learning through integration of technology is that the pedagogy or educational concept of the school is taken as the point of departure in finding out what is pedagogically desirable (i.e. what type of teaching and learning is desired) in this particular school, before investigating what technology might promote this. Previous studies have shown that in schools with different educational concepts developing their technology use this way engendered different types of technology use (de Koster, Kuiper, & Volman, 2012), while the extent of integration of the developed technology use in all schools was similar (de Koster, Volman, & Kuiper, submitted). There have not been any studies however, investigating to what extent such a concept-guided approach to technology development would lead to lasting, i.e. sustainably integrated technology use in schools with different educational concepts and how possible differences between school types can be explained.

**This study**

The context for this study is a small-scale two-year project in which teachers at five primary schools in the Netherlands with different educational concepts developed technology-enhanced learning arrangements through a concept-guided approach. The learning arrangements were developed in line with the schools’ educational concepts, thus aiming at a profitable fit between the technology use and the school’s educational concept (Zhao et al., 2002, de Koster, Kuiper, & Volman, 2012). At each school a team of teachers was supported in designing and implementing up to four technology-supported learning arrangements. In this present study we investigated at two schools whether the learning arrangements that were realised proved to be sustainable after the project ended. One year after the project we went back to one ‘traditional’ and one ‘innovative’ school, in order to investigate how much of the technology use that was developed during the project was still visible in the school one year after the project ended (Research question 1). With this first research question we focus on the
dimension of the longevity of the innovations (Datnow, 2005). As the further development and fine-tuning of innovations is also suggested as a dimension of sustainability we investigated if and how the technology use was developed further during this year after the project (Research question 2). With this research question we focus on what we propose to label as the progressive dimension of sustainable technology innovation. Finally we explored: are there any differences in sustainability between the two schools and how may these be explained in relation to the schools’ educational concepts? (Research question 3).

Method

Context of this study

Five primary schools participated in the project that formed the context for this longitudinal study. During the two-year project a team of teachers at each school designed, developed and realised up to four technology-enhanced learning arrangements. The teaching and learning practices at all participating schools met the quality standards of the Dutch Inspectorate of Education, as stated in the inspectorate’s reports of the schools. The two schools that participated in this present study each realised four learning arrangements during this project. The learning arrangements consisted of a lesson plan, including goals, activities and technological tools, and could concern any school subject and any type of technology use. Brief descriptions of these learning arrangements can be found in the results section. The teachers were coached by educational consultants with expertise concerning various processes of educational innovation who worked for an educational consultancy organisation. Each school was coached by a different consultant. At the start of the development process the consultant would support the teachers in reflecting on their school’s educational concept and on ways in which technology could be used to support this concept. Based on this reflection the teachers designed up to four technology-enhanced learning arrangements, supported by their consultant throughout the project. These consultants were instructed to prioritise the teachers’ sense of ownership in designing the learning arrangements.
The researchers were not involved in the design phase of the project, in order to minimise researcher bias.

The teacher-as-designer approach was expected to further promote the implementation and integration of the designed learning arrangements by installing a sense of ownership in the teachers (Handelzalts, 2009; Ketelaar, Beijaard, den Brok, & Boshuizen, 2013; Maher, 1987). The project focused on the level of the classroom, although schools were free to involve the whole school in the innovations.

Setting

The five primary schools that participated in this project were labeled as either ‘traditional’ or ‘innovative’. These labels only referred to the schools’ views of learning and teaching in general, not to their ICT use before or during their participation in the project. At each school two or more teachers participated over a period of two school years. The grade levels of their classes varied from second to sixth grade. In this study we describe the cases of the ‘traditional’ school, here referred to as the Princess Amalia School, and the ‘innovative’ school, referred to as the Beehive School. The other schools had either left the project before it was ended or could no longer participate because of organisational changes in the meantime. Typical for the ‘traditional’ schools in this project was that educational goals were largely pursued through the use of teaching and learning materials with a more or less fixed content. Most instruction was given to the whole class, following a rather strict time schedule, dictated by the teaching materials and the standardised tests that were used. After instruction, pupils mostly worked individually or in pairs on assignments or exercises directly linked to the textbook content. Remedial instruction was given in smaller groups, informed by test results. In general, pupils’ activities were mainly determined by the teacher.

The Beehive School was labelled ‘innovative’ in this project. At the ‘innovative’ schools the teachers typically aimed at making learning attractive and engaging for pupils by giving them control over their learning process and by inquiry learning activities. The classes were deliberately multi-aged, in order to give pupils the opportunity to learn with and from each other. Subject matter at the Beehive School was
mainly taught in the form of workshops, as a regular part of the school day. Standard teaching and learning materials were primarily used as a general source of content and exercises. Enabling pupils to choose activities that fit their dominant intelligence(s) (Gardner, 1999) was expected to make education more meaningful to students. The learning arrangements of the traditional Princess Amalia School are referred to as A1-A4, and those of the innovative Beehive School as B1-B4.

**Design, instruments and data collection**

This multiple case study focused on the cases of these two schools and consisted of two measurements, one at the end of the project (M1) and one a year later (M2). The main source of data were in-depth semi-structured focus group interviews with three teachers at each of the schools, held at both measurements. The focus groups at both schools and both measurements consisted of three teachers who were actively involved in the project by participating in the development and/or realisation of the learning arrangements. In the interviews we focused on the dimensions longevity and progressive innovation that were derived from the literature on sustainability of technology use. The topics in the interview protocol therefore included:

a) The technology use that had been developed during the project
b) Its longevity (is it still visible in the school)
c) Its progressiveness (has it been further developed; e.g. fine-tuned or ‘next generation improvements’).

Table 1 shows which learning arrangements the teachers in the interviews had been most actively involved in and which grades they were teaching at the time of M1 and M2. The teachers who had carried out the first learning arrangements (A1 and B1) had both left the project before the end of the project and did therefore not participate in the focus group interviews.
Table 1. Composition of focus groups per school: learning arrangement(s) and grades per teacher

<table>
<thead>
<tr>
<th>Learning arrangement</th>
<th>Grade(s)</th>
<th>Learning arrangement</th>
<th>Grade(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher 1</td>
<td>A2 + A4</td>
<td>3 + 4</td>
<td>B2 + B3</td>
</tr>
<tr>
<td>Teacher 2</td>
<td>A3</td>
<td>6</td>
<td>B4</td>
</tr>
<tr>
<td>Teacher 3</td>
<td>A3</td>
<td>4 + 5</td>
<td>B3</td>
</tr>
</tbody>
</table>

The teachers’ accounts in the focus group interviews were checked against descriptive data concerning the use of technology in the learning arrangements throughout the project, collected through individual interviews with teachers, videotaped whole-lesson classroom observations and registration of technology use by teachers and pupils (logs, registration forms). These data were focused on what technology was used, how it was used and with which goals. The learning arrangements are described briefly in Table 2 and 3. They have been analysed and described more elaborately in our previous studies (de Koster, Kuiper, & Volman, 2012; de Koster, Volman, & Kuiper, 2013).

Analysis

The focus group interviews were transcribed and subjected to content analysis (Huberman & Miles, 1994). We analysed all fragments from both measurements that concerned the topics mentioned above, using the labels ‘longevity’ and ‘progressive integration’. The label ‘longevity’ was assigned to fragments that indicated that a technology use was still visible (Research question 1). The construct of longevity was made more specific by analyzing whether all the central elements of the technology use in each learning arrangement were still visible, i.e. whether the same tools were still used and in the same way, aiming at the same goals as initially intended. Information on tools and their initial use and goals was derived from the descriptions of the learning arrangements and in particular the teachers’ intentions and expectations of the learning arrangements described therein (de Koster, Kuiper, & Volman, 2012). The label ‘progressive integration’ was used to answer Research question 2: if and how the
technology use that was still visible a year after the project was developed further during the year after the project ended. Fragments that indicated that the technology use in the learning arrangements had been developed further in order to improve it in any way were labelled as ‘progressive integration’ (M2). In order to find differences between the schools with regard to the sustainability of their technology use we compared the found sustainability in terms of longevity and progressiveness. Next we used grounded theory (Glaser & Strauss, 1999) to analyse the focus group interviews again in order to explore possible explanations of the differences that were found (Research question 3).

**Results**

The results for the ‘traditional’ school are discussed first, followed by the results for the ‘innovative’ school. In each section we first give a brief characterisation of the technology-rich learning arrangements that were developed and realised at this school during the project and then compare (within-case) what was still in use by the end of the project (M1) with what was still in use a year after the project ended (M2) (research question 1) and discuss whether or not the developed technology use showed any further development (research question 2). Finally we compare the findings of the two schools and look at possible explanations for any differences found.

**Sustainable integration of technology use at the ‘traditional’ school**

During the course of the project four relatively simple learning arrangements with one or two tools per arrangement were realised at the Princess Amalia School. Table 2 gives a brief description of the technology use as designed and realised during the project, including the goals they aimed at, and what was still in use by the end of the project and one year later (longevity).
<table>
<thead>
<tr>
<th>Code</th>
<th>As designed and initially realized</th>
<th>Goals</th>
<th>Still in use by end of project (M1)</th>
<th>Still in use a year later (M2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Individual exercises and tests with mathematics exercise and test software, on desktop computers in the classroom; grade 5 and 6</td>
<td>Make exercises more engaging, resulting in higher grades.</td>
<td>Exercises are still used, tests have been abandoned</td>
<td>Software has been abandoned completely</td>
</tr>
<tr>
<td>A2</td>
<td>Interactive classroom instruction on writing and spelling on IWB; some pupils are asked to do an exercise designed by the teacher on the IWB; grade 3</td>
<td>More active engagement and motivation of pupils during instruction, resulting in higher grades.</td>
<td>The interactive use of IWB in writing and spelling instruction is limited</td>
<td>The interactive use of IWB in writing and spelling instruction is very limited.</td>
</tr>
<tr>
<td>A3</td>
<td>Individual exercises and tests with reading comprehension exercise and test software on laptop and desktop computers in the classroom; grade 6</td>
<td>Make exercises more engaging, resulting in higher grades, in particular for lower achieving pupils.</td>
<td>Exercises and tests are still used</td>
<td>Exercises and tests are still used</td>
</tr>
</tbody>
</table>

Table 2. Longevity of technology use at the Princess Amalia School. M1 and M2 compared
Assignments (on cards) in social studies, involving web searching, processing and presenting information, in pairs; grade 3

Pupils develop web skills: searching, reading search results, comprehending information. Pupils memorize the information found on the web. Pupils learn from each other.

Focus on developing web skills persists

Focus on developing web skills persists and has spread to higher grades

Note: IWB = interactive whiteboard

Longevity at the ‘traditional’ school

The use of the math practice software in arrangement A1 was still visible at the end of the second project year, but was abandoned after the project. It had not met the teachers’ expectations and had not been replaced by other software.

M2 T2: [The software] we eventually didn’t buy because it just didn’t add enough value. […]
T1: In [the software] the tests just didn’t work properly, not like we had hoped.
T3: And also the extra enrichment… that did not add so much either. […]

The use of the interactive whiteboard (IWB) to support language instruction lessons (A2) continued, yet the interactive features that had formed the core of the initial learning arrangement had been abandoned. In the language lessons only scanned exercises from the workbook were still being used.

M2 T1: I don’t do those things with the [IWB] software anymore. What I did then, scanning a language lesson, typing phrases and making parts disappear… […] this in green and that in red, having the children come up to the board…
T2: You still use it, but not...
T1 ... you know, things that made them think: ‘wow, I didn’t know that was possible!’ It’s still possible, I just don’t do it anymore.

The teachers mentioned time constraints as the main reason for this.

M2 T2: [...] we had as a goal to make a few lessons together. So that I would know too, because [T1] knows it, that I would know too what’s possible and how to do it.
T1: But still, if you would know it now, do you have time to make lessons? I wouldn’t know when. At night, right? That’s the only moment…

The teachers also claimed that no extra time was created for helping other teachers develop an interactive use of the board.

M2 T2: [...] we had set our personal goals on: we’re at least going to make sure we have prepared a few lessons, so that I also know..., and then we can also show these lessons to the others [...] So then you share your knowledge and then the other teachers can move on from there. But the time isn’t created for it, so it sort of stands still.

In the M1 interview the teachers mentioned plans to eventually reinstate the interactive use of the IWB, for instance by designing some interactive lessons together. This had not yet been realised a year later and no concrete plans were mentioned to change this. The use of the reading software (A3) was continued as intended, since it functioned well and was appreciated by both teachers and students. The school had invested in continuing the licence for the software and it was used in the same way as during the project. The focus on using the internet for school projects (A4) had continued and had spread to all upper grades. The teachers reported that now in all upper grades more attention was paid to the development of students’ information skills.
T1: You know what we did then with searching, with Google and all… Well, that’s been discussed […] with all grades. That they have to learn the searching especially. And now we start with that in grade 3. I had grade 3 back then, but now up to grade 6…

Most of the laptops that were used in this learning arrangement started to fail shortly after the project ended and had been replaced by fixed computer work stations in the school’s corridors. At M2 these computers were mainly being used for doing exercises and for science projects, similar to what the laptops had been used for during the project.

In summary, one out of four learning arrangements at the Princess Amalia School (A3) was still used as it had been designed and could therefore be considered sustainable in terms of longevity one year after the project ended. The IWB was partly still being used in language lessons (A2) but this use had been downgraded to a much less interactive form. The interactive features of the IWB had not been replaced with another tool or application. In one arrangement (A4) the main tool (laptops) had to an extent been replaced with another tool (desktop computers) and had spread to higher grades. Arrangements A2 and A3 could therefore be seen as partially sustainable in terms of longevity. One arrangement had been abandoned completely (A1) and was therefore seen as not sustainable.

**Progressive integration at the ‘traditional’ school**

By the end of the project the teachers at the Princess Amalia School expressed the wish to continue with what they had developed and that all classrooms would get an IWB and more laptop computers. They expressed mixed expectations, however, about the further development of technology use and did not mention any specific plans when asked how they were going to continue after the project ended.

T1: I don’t think there will be a lot of change anymore. The way we were teaching today, that’s what it looks like every day.
T3: I think eventually it will become even more. I mean, we all get more experienced at it. […]

T1: Eventually you’ll have a database of information on your computer that will never go away. Many more classes will have it.

T3: So I think it will only be more comprehensive and that it will be more self-evident that we [work with technology].

The teachers’ remarks during the M2 interview however indicate that no new technology-supported learning arrangements were developed after the project and apart from the spreading of A2 and A4 the learning arrangements from the project had not been further developed. Teacher 1 remarked that everything they had been missing before the project had now been realised and further development was not needed.

M2    T3: We haven’t started anything new really, after the project. In terms of technology.

T1: Because it’s all working. What we’ve done. That was what we could develop further and now it’s all done, that’s what I feel.

The teachers were satisfied with what they had developed. Teacher 1 suggested that it would be best to first optimise what they were doing before developing anything new. Sustainability in terms of progressive integration was therefore not found and did not appear to be on the teachers’ or the school’s agenda.

**Sustainable integration of technology use at the ‘innovative’ school**

At the ‘innovative’ Beehive School we found four quite complex technology-supported learning arrangements, encompassing a great variety of tools. Table 3 gives a brief description of the technology use as designed and realised during the project, along with what was still in use by the end of the project and one year later (longevity).
<table>
<thead>
<tr>
<th>Code</th>
<th>As designed and initially realized</th>
<th>Goals</th>
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<th>Still in use a year later (M2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Pupils use digital cameras to make pictures and video clips around a theme, make presentations with their pictures, their video clips and information from the web, and give presentations on the IWB; grades 2 through 4</td>
<td>The use of self-made digital images makes the theme ‘friendship’ meaningful and engaging to pupils and facilitates the realization of the intended learning results.</td>
<td>Use of digital cameras and student presentations on IWB is continued in a different context</td>
<td>Use of digital cameras and student presentations on IWB is continued in a different context</td>
</tr>
<tr>
<td>B2</td>
<td>Pairs of pupils perform a chemical experiment and record and edit a video of the experiment, and show videos on the IWB to the class; grades 4 through 6</td>
<td>Making a video of their own experiment enables pupils to co-construct and share knowledge. Make learning more engaging.</td>
<td>Making video clips has continued</td>
<td>Making video clips has continued in a different context</td>
</tr>
<tr>
<td>B3</td>
<td>Pupils (individual, pairs, small groups) practise multiplication tables through non-digital games, available in a database on school’s digital network; teacher makes an instruction film for a game with grade 6 pupils;</td>
<td>Practising multiplication tables independently. Being able to choose games according to intelligence improves meaningfulness to pupils.</td>
<td>Use of database has been suspended</td>
<td>Use of database is still suspended.</td>
</tr>
</tbody>
</table>
### B4

Pupils (pairs, small groups) photograph groups of objects with digital photo cameras. Teacher prints photographs and pupils use photographs to make multiplication booklets; grade 2

<table>
<thead>
<tr>
<th>Action</th>
<th>Use of digital cameras for making multiplication booklets has continued</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taking photos of groups of objects and using the photos enables pupils to grasp the basic principles of multiplication tables.</td>
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</tbody>
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**Longevity at the ‘innovative’ school**

During the year after the project ended learning arrangements B1 and B2 had continued, yet in a slightly different context. This will be described further in the next sub section as examples of progressive integration. The teachers indicated at M1 that their appreciation and use of the IWB, which had played a pivotal role in presenting and discussing student products in B1 and B2, had gradually decreased. Although they did not abandon its use altogether they realised that they spent more time doing small group work with the laptop computers than whole-class instruction with the IWB.

**M1**

T1: For me that’s not the first thing that I would miss if it wasn’t there. I think it’s very useful, I do see its added value, but actually I find the laptops far more important than the IWB.

This continued after the project ended. At M2 Teacher 2 indicated that the presenting function of the IWB had been partially taken over by the laptops. Arrangement B3 had been suspended by the end of the project and had still not yet been realised at M2. The arrangement had been designed to be used in an electronic learning environment (ELE)
that had not been realised yet. At M2 the teachers still expressed the wish to continue with it when the ELE was realised.

M2 T3: [the school board] are involved in this project of… […] about that ELE.
T1: Yeah. [the school’s technology supporter] is involved in it, right? It’s another pilot that we’re participating in. […] So such a database is still… some things are still unpractical at the moment.

Arrangement B4 was still used as it had been designed and realised during the project.

In summary, one out of four learning arrangements at the Beehive School was still used as it had been designed (B4) and was therefore considered sustainable in terms of longevity. Two arrangements had continued in a different context and with a shift from presenting student products on the IWB to presenting on the laptops (B1 and B2). These were therefore considered partially sustained. One arrangement (B3) had been suspended by the end of the project because the ELE for which it had been designed had not yet been realised. This had not changed a year later. Therefore the longevity of this learning arrangement could not be assessed as either sustained, partially sustained or abandoned.

**Progressive integration at the ‘innovative’ school**

Arrangements B1 and B2 continued in the context of new projects. Students continued to make movie clips. They presented these videos on the IWB and on laptops but also incorporated these clips for instance into a self-designed website.

M2 T1: I organised a pop concert with my pupils last year. And all pupils made a video clip and a song on the computer. And made a photo-shoot and made invitations through some website and a website for their own band. […] What I did back then [the chemical experiments, B2], I continued with our pop concert. Back then the basic idea was that pupils could watch each other’s
clips, and also learn to work with Moviemaker, making their own clips. And now I organised it differently and it was more successful. Because now I knew what could go wrong. I’m also a lot less apprehensive about making clips with them, because I just know: we can do it.

The teacher’s remark that she ‘organised it differently and it was more successful’ points at her effort to fine-tune this technology use to make it fit even more with her learning goals, part of the dimension of progressive integration. Another example of progressive integration is seen with regard to arrangement B3. Although it was still suspended at M2, the teachers reported it had led to a spin-off:

M2 T3: Triggered by the instruction film that [T1] made [for one of the exercises in the database] I went a step further last year. Back then she had made it herself with the pupils. I made another instruction film of a different activity. I had the pupils do it all themselves. So I had the pupils write the script, construct a kind of game, film it and edit it as well. So that was basically a sequel to that first film.

The teacher’s remark that she ‘went a step further’ indicates an example of ‘next generation improvements’, another aspect of progressiveness. So to summarise we found two examples of progressive integration of the developed technology use at this school.

**Differences and possible explanations**

**Differences in sustainability in terms of longevity**

The findings with regard to sustainability in terms of longevity of the technology-enhanced learning arrangements and the use of laptops and IWBs presented in 3.1 and 3.2 are summarised in Table 4 in order to make a comparison between the schools.
Table 4. Sustainability in terms of longevity per learning arrangement / tool per school

<table>
<thead>
<tr>
<th></th>
<th>Sustained</th>
<th>Partially sustained</th>
<th>Suspended</th>
<th>Abandoned</th>
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<tbody>
<tr>
<td><strong>Princess Amalia School</strong></td>
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<tr>
<td>A1</td>
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<td>X</td>
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<td>A2</td>
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<td>A3</td>
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<td>A4</td>
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<tr>
<td><strong>Beehive School</strong></td>
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<tr>
<td>B1</td>
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<td>B2</td>
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Table 4 shows that the learning arrangements at the Princess Amalia School were either sustained as designed (one arrangement), partially sustained (two arrangements) or abandoned (one arrangement). Noticeably in one arrangement at the Princess Amalia School that was partially sustained the element that was abandoned was not replaced (interactive use of the IWB in A2), while in another arrangement it was replaced by other technology use (desktop computers to an extent replaced the use of the IWB in A4). At the Beehive School the learning arrangements were either sustained (one instance), partially sustained (two instances) or suspended (one instance). The technology use that was only partially sustained in two arrangements was to an extent replaced with other technology use (the use of laptops to an extent replaced the use of the IWB in B1 and B2). This shows that although at both schools only one arrangement had been sustained as designed and two had been partially sustained the developed technology use seemed the least sustainable in terms of longevity at the Princess Amalia School. Here one of the arrangements had been abandoned completely and in one of the partially sustained arrangements the abandoned element had not been replaced by other technology use while at the Beehive School no arrangements or elements of arrangements had been abandoned without being replaced by other technology use.
Differences in sustainability in terms of progressive integration

Across both schools the sustainability in terms of progressive integration could be described as either progressive (improvements had been made to better serve the intended purpose, e.g. students making videos in different contexts at the Beehive School), static (the technology use was continued as it had been designed) or regressive (the technology use had regressed to a form that seemed to have lost some of its intended purpose, e.g. the less interactive use of the IWB in arrangement A2 at the Princess Amalia School). We use these terms to make a comparison between the schools. The findings with regard to sustainability of the technology use in the learning arrangements in terms of progressive integration presented in 3.1 and 3.2 are summarised in Table 5.

Table 5. Sustainability in terms of progressive integration per learning arrangement per school

<table>
<thead>
<tr>
<th>Princess Amalia School</th>
<th>Progressive</th>
<th>Static</th>
<th>Regressive</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>A2</td>
<td>-</td>
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<td>X</td>
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<tr>
<td>A3</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>A4</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beehive School</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B2</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B3*</td>
<td>(X)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B4</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
</tbody>
</table>

*although this arrangement was suspended it did lead to a ‘next generation’ spin-off

This table clearly shows a difference between the two schools. The technology use in the learning arrangements at the Princess Amalia School tended to be either static or even regressive. No examples of progressive integration were found at this school. At the Beehive School we saw two examples of progressive integration and, although it
had been suspended, even arrangement B3 had led to a ‘next generation’ spin-off. Although the use of the IWB in two learning arrangements had become less intensive these arrangements were labeled as progressive rather than regressive because its use had been replaced by another tool and the use of making videos by students had been developed further. One arrangement had remained unaltered. In summary the technology use at the Beehive School appeared more sustainable in terms of progressive integration than at the Princess Amalia School where not progressive integration was found.

A possible explanation for differences in sustainability

The main picture that emerges from these findings is that the technology use in the learning arrangements at the ‘innovative’ Beehive School was somewhat more sustainable in terms of both longevity and progressive integration than at the ‘traditional’ Princess Amalia School. Possible explanations for these differences were found in the teachers’ remarks about further development of their technology use. When discussing how the learning arrangement that had been suspended because the ELE had not been realised yet the teachers’ remarks showed a more general ambition at the Beehive School to develop their technology use further.

M2 T2: Now it’s all on the network. And when we have [the ELE], then it’s just...
T1: Then it’s supposed to be a lot easier. Because we want to do a lot more with it than we can do now.
T2: Right. The technological developments are holding us back. Because we’re stuck with our network.

This contrasts with the Princess Amalia School where the teachers were satisfied to continue with what they had developed, as mentioned in 3.1. One of the teachers at the Beehive School summarised the continuing development of their technology use as follows.
M2 T1: For us it didn’t stop after [the project]. We just continued and still ask ourselves: […] what else can we do with technology in the school?

As examples of developments the teachers at the Beehive School mentioned the school’s participation in other technology-related projects, for instance a one-laptop-per-child experiment, and the enrollment of one of the teachers in a worldwide networking programme for innovative teachers. The continuing development of their technology use played an important part in their aspiration to further develop towards an even more student-directed pedagogy by providing students with more opportunities to practice at home and by deepening students’ independent learning.

M2 T3: To deepen. So that children can do things even more independently. So that the teacher steps even further away from the IWB, in a way. And coaches more, I think.
T2: Yeah, tailor-made learning, right?
T3: Exactly.
T1: Plus, I still feel that you can’t really not keep developing this further. Because this is something we just… This is our society.

Conclusion

In this double longitudinal case study we explored if and how newly developed technology use became sustainably integrated in the classroom practices of a ‘traditional’ and an ‘innovative’ primary school one year beyond their participation in an innovation project and how possible differences in sustainability might be explained. The schools were among five schools that participated in a two-year project in which teachers developed their technology use in a concept-guided way. This meant developing technology use that might support and enhance teaching and learning in a way that fitted the school’s education concept. Based on focus group interviews with the teachers involved and analysis of the learning arrangements developed in the two schools, sustainability was measured by investigating whether or not the developed
technology use was still visible in the schools’ classroom practices one year after the project ended (sustainability in terms of longevity) and if and how the technology use was developed further in the course of this year (sustainability in terms of progressive integration). After analyzing the sustainability at each school separately we zoomed in on differences and their possible explanations.

*Sustainability in terms of longevity and progressive integration: differences and possible explanations*

Both in terms of longevity and progressive integration the technology use in the learning arrangements at the ‘innovative’ Beehive School was more sustainable than at the ‘traditional’ Princess Amalia School. At the ’traditional’ school one of the arrangements had been abandoned completely and in one of the partially sustained arrangements the abandoned element had not been replaced by other technology use. At the ’innovative’ school one arrangement was suspended and no arrangements or elements of arrangements had been abandoned without being replaced by other technology use serving the same purpose. At both schools only one learning arrangement was sustained as it had been designed. In analyzing the progressiveness of the integration we distinguished between progressive (improvements had been made to better serve the intended purpose), static (the technology use was continued as it had been designed) and regressive integration (the technology use had regressed to a form that seemed to have lost some of its intended purpose). The technology use in the learning arrangements at the ‘traditional’ school tended to be either static or regressive. No examples of progressive integration were found at this school. At the ‘innovative’ school two learning arrangements showed progressive integration and the arrangement that had been suspended had led to a ‘next generation’ spin-off.

A difference between the schools in the teachers’ general attitude to further developing the school’s technology use is suggested to account for the differences that were found in the sustainability. At the Princess Amalia School the teachers expressed a general satisfaction with what had been accomplished by participating in the project and no specific plans for future development of their technology use were mentioned. At the
Beehive School on the other hand the further development of the technology use that had been developed during the project seemed to be a part of a more general tendency to constantly look for new ways to enhance their teaching and to incorporate technology in this development.

Discussion

We conclude that, based on the teachers’ statements in the interviews, the main difference between the schools is found in the teachers’ (and possibly the schools’) attitude towards technological innovation. For this attitude Van Braak (2001) uses the term ‘technological innovativeness’, defining it as a positive attitude towards the need to introduce technology and a willingness to realise this introduction of technology in the classroom. This technological innovativeness could of course be expected to be part of the culture of a school that was labelled as ‘innovative’ on entering this project. Yet it could have been expected from the ‘traditional’ schools as well, since this school too joined the project with the intention to further its technology use. At the ‘traditional’ school, however, we found an innovativeness that seemed much more limited, as the teachers’ ambitions explicitly focused on optimizing their current technology-enhanced practices rather than on taking their technology use a step further or developing new technology-enhanced learning arrangements.

The lower sustainability at the ‘traditional’ school might also be attributed to the type of technology use that was developed at this school. What this technology use adds to the teachers’ practices seems less essential than at the ‘innovative’ school.

The regression of technology use that was found at the ‘traditional’ school, i.e. lessons with the IWB becoming less interactive, could be described as a ‘lethal mutation’, as described by Brown and Campione (1996). On the other hand this mutation could also be seen as their IWB use becoming more ‘traditional’ and therefore becoming better suited to the teaching and learning at this school. The teachers’ apparent ambivalence regarding the loss of this interactivity, expressing the wish to make the lessons more interactive again yet apparently not ‘going the extra mile’ to achieve this goal, may show that the intensification of their technology use presented them with a dilemma.
between staying true to their school’s ‘traditional’ pedagogical principles and the more ‘innovative’ affordances of the tool.

We did on the other hand see one ‘progressive’ development at this school, namely the spreading of some arrangements to other grades. This can be seen either as an aspect of progressive integration (spreading within the school as development of technology use in a quantitative sense) or as a dimension of sustainable technology integration in its own right, as an indication that the technology is becoming more integrated in the school as a whole (Coburn, 2003).

This reflection leads us to add the following to our conclusions about the sustainability of the technology use at these two schools. In terms of progressiveness the ‘innovative’ school appeared to be focused more on further developing their technology use, which seemed to be part of a larger aim to further develop their teaching and learning practices. At the ‘traditional’ school the teachers appeared to focus instead on staying close to their tried-and-tested teaching methods rather than on development.

**Limitations and further research**

With only one school of each school type in this study and a strong reliance on the teachers’ accounts of their technology use we can of course only draw very tentative conclusions. It does seem worthwhile to further investigate the possible relationship between school educational concept and technological innovativeness as a basis for better understanding and supporting the sustainable integration of technology in schools with different educational concepts. Also, as the real challenge of sustaining an innovation starts after the support of the innovation project has been withdrawn, these schools should be followed beyond the first year after participation in such a project. Another limitation of the study was that the analysis of the technology use one year after the project was based solely on the teachers’ accounts in the focus group interviews. For future research on the further development of technology use we recommend to use direct measurement of the technology use and to also include more aspects of the school context in the investigation.
Reflecting on our findings we propose to expand the existing models for investigating sustainability of technology use in the classroom. With regard to the aspect of ‘longevity’ a question that needs to be addressed is whether an innovation that has been abandoned is replaced by something else to support the initial goal of the innovation. With regard to ‘progressiveness’ we need to investigate whether the innovation is further developed, including fine-tuning and/or next generation improvements, or remains at it is (in this study labeled as static sustainability) or even regresses. The spreading or institutionalisation of technology use within the school could be studied either as another aspect of progressive integration or as an aspect of sustainability in its own right.

With regard to the ‘traditional’ school in this study it would be worthwhile to investigate whether its technology use stays static over a longer period of time or if there is eventually some further development. Apart from the apparently more limited innovativeness at this school and the seemingly less profound contribution of the type of technology use that it developed there is another factor that may hinder progressive development of technology use in this type of school. There is limited room for curriculum development by teachers in a strongly textbook-driven curriculum, as some remarks of the teachers at the ‘traditional’ school indicated. In such a pre-structured curriculum there is little time for the teachers to take on the enterprise of continued development of a learning arrangement and of the professional development that is needed to do this. Further studies in this type of school will need to pay attention to all of these concept-specific issues, as well as to the extent to which the integrated technology use actually helps to improve these practices, as this is essentially the goal of innovation.

Despite the limitations of this study these findings raise some poignant questions that need to be addressed in further research in order to ‘fine-tune’ our understanding of and ability to support the sustainability of technology integration in relation to different educational concepts.
Chapter 6  Summary and general discussion

There have been considerable efforts over the past few decades to promote and facilitate the use of classroom technology, which can include anything from drill-and-practice software for maths and literacy skills, to students presenting their own videos on an interactive whiteboard or learning in a virtual reality setting. The expectations regarding the possible benefits of ICT for teaching and learning are high (Aesaert, Vanderlinde, Tondeur, & van Braak, 2013; Dede, 2010; Lemke, Coughlin, & Reifschneider, 2009; Voogt & Pelgrum, 2005; Voogt & Roblin, 2012). Yet the expected integration of technology use and its subsequent effects on teaching and learning in most schools are not being realised (Lemke et al., 2009; OECD, 2015).

The overarching purpose of this dissertation was to investigate whether concept-guided development of ICT use in education is a promising approach that can promote the integration of technology into teachers’ practices. A growing body of literature indicates a crucial link between pedagogical beliefs and the use and integration of ICT (Ertmer, 2005; Hermans, Tondeur, van Braak, & Valcke, 2008; Kim, Kim, Lee, Spector, & DeMeester, 2013; Liu, 2011; Zhao, Pugh, Sheldon, & Byers, 2002). Research has shown that a good fit between the educational concept of the school and its ICT use is an important condition for the successful integration of ICT into educational practices. Zhao, Pugh, Sheldon and Byers (2002) found that a minimal distance between the ICT innovation and the school’s culture and practice promotes the integration of the innovation. Similarly, Tolmie (2001) showed that how and to what effect ICT resources are used depends on how well they fit in with the established patterns of activity in the school, while according to Niederhauser and Stoddart (2001) teachers are inclined to apply technology in a manner that is consistent with their personal perspectives about curriculum and instructional practice.

Concept-guided development of technology use aims to utilise the mechanism that teachers tend to use technology in ways that fit their teaching practices by starting from
a reflection on the school’s educational concept – i.e. the educational views (values, beliefs, perspectives) on which its classroom practices are based. The purpose of this approach is to develop technology use that fits the school’s educational concept and thereby increase chances for successful integration of the technology use. Thus it aims to contribute to helping schools to close the gap between the promise of classroom technology and the realisation of this promise.

The research presented here was conducted in the context of a project\(^6\) in which teams of teachers in five primary schools in the Netherlands participated. Two schools had a ‘traditional’ educational concept, the label ‘traditional’ referring to a fixed curriculum and a strongly teacher-directed approach. The other three schools had an ‘innovative’ educational concept, which meant that these schools had a more open curriculum and a student-centred approach.

The schools developed ICT-rich learning arrangements in a concept-guided way, so that the ICT use would fit their educational concepts. A learning arrangement would consist of a lesson plan, and could concern any school subject or combination of subjects. The technology use in a learning arrangement could entail anything from the use of ‘drill-and-practice’ software to the use of a wide range of technological tools to support a variety of learning activities in an inquiry-based project. Across the schools a total of seventeen learning arrangements were developed during the project.

It was expected that by taking the school’s educational concept as a starting point for developing new ICT use, this concept-guided approach would promote the integration of classroom ICT use. We investigated the resulting technology use and its integration into the teachers’ classroom practices in the participating schools. The overarching research question was:

*To what extent does a concept-guided approach in schools with either a ‘traditional’ or an ‘innovative’ educational concept contribute to the development of ICT use that becomes integrated into the teachers’ classroom practices?*

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\(^6\) This was called the Cumulus project, initiated by educational consultancy company APS and financed by the Dutch public organisation for education & ICT Kennisnet and APS. VU University Amsterdam and HAN University of Applied Sciences supplied the research staff.
Four studies were conducted to answer the main research question. In this final chapter the main findings and conclusions of these four studies are summarised and the conclusions are discussed with regard to their implications for theory, practice and further research. Finally, some overall conclusions are drawn with regard to the main research question.

Summary of the main findings and conclusions

The first two studies, Part I of this dissertation, focused on describing the technology use that resulted from the concept-guided approach in the participating schools. ICT can support different types of teaching and learning (Niederhauser & Stoddart, 2001; Higgins & Spitulnik, 2008; Inan, Lowther, Ross, & Strahl, 2010). Both learner-directed and teacher-directed learning can be supported by ICT (Ten Brummelhuis & Kuiper, 2008) and it can facilitate the individualisation of learning processes as well as support learning within a learning community (Volman, 2005). In our first study (chapter 2) we therefore aimed to answer the following research question: To what extent does concept-guided development of ICT-enhanced learning arrangements in primary schools lead to distinguishable types of ICT use?

The ICT use was operationalised in terms of the tools that were used, the activities in which they were used and the goals that were expected to be achieved through the ICT use. The study included case studies of all five schools that participated in the project. The results of the study showed that concept-guided development of ICT-enriched learning arrangements indeed resulted in clearly distinguishable types of ICT use in the two types of schools. At the two ‘traditional’ schools typically only one or two ICT tools were used within one learning arrangement, mainly supporting the use of standard teaching materials with fixed learning content and a strongly teacher-directed approach.

The learning arrangements at the three ‘innovative’ schools were characterised by use of a wide range of ICT tools that supported explorative, open-ended activities with considerable input from the students. At one school visual tools played a significant
role; at the other schools the internet and other tools that facilitate explorative activities were used most prominently. Some ICT tools, primarily the computers and the interactive whiteboard (IWB), were used in both school types, yet in different ways, reflecting the differences between the two school types. To an extent the teachers in both school types also formulated similar goals for the ICT use they developed. Across the school types the teachers formulated goals with regard to enhancing student motivation, learning results, self-directed learning and differentiation. Yet the different ways in which the tools were used to work towards these goals seemed to reflect the different expectations with regard to ICT and learning that the schools have. At the ‘traditional’ schools, enhanced motivation was expected because of the variation in instructional and exercise formats facilitated by ICT, whereas the teachers at the ‘innovative’ schools expected higher motivation through enhanced meaningfulness of learning activities. With regard to learning results, the ‘traditional’ schools focused on knowledge acquisition through ICT, while the ‘innovative’ schools mainly focused on the development of skills. As for self-directed learning, at the ‘traditional’ schools, the focus was on performing learning tasks with less assistance from the teacher, whereas at the ‘innovative’ schools, ICT was expected to give students more control over the content of their learning activities. Finally, the ‘traditional’ schools designed ICT-enhanced learning arrangements that enabled differentiation with respect to cognitive aspects, while at the ‘innovative schools,’ differences in learning style and personal interests were facilitated by the use of ICT.

From these findings we conclude that the ICT tools, activities and goals in general reflected the different school concepts that set the school types apart. The findings also suggest that the ‘traditional’ schools developed less complex use of technology that seemed to be fairly easily implemented, while the ‘innovative’ schools designed rather complex use of technology, which seemed to hinder its implementation. This issue was further explored in the third and fourth study.

The second study (chapter 3) focused on the interactive use of the interactive whiteboard (IWB), which was used in both school types, as the first study showed. One
of the distinctions between the two school types was the extent of the learner-centredness of teaching in the schools, i.e. the extent to which students had an active role in their learning process. This distinction was also expected to be visible in the interactive use of the IWB. This led to the main research question for this study: What types of classroom interactivity does the IWB support in ‘traditional’ and ‘innovative’ schools that develop their ICT use in a concept-guided way?

Two ‘traditional’ and two ‘innovative’ schools were included in this study. Video-observations of three lessons per school type were analysed. We focused on whole-class interactions between teachers, students and the IWB. This type of interaction was most prominent in the IWB-supported lessons that were observed and could therefore be compared most meaningfully. The analysis distinguished between the operation of the board, control of the content on the board and the type of classroom dialogue while using the board.

In the lessons at the ‘traditional’ schools the most common interactivity pattern found was teacher operation of the IWB together with teacher-controlled IWB content and dialogue that focused on knowledge transmission. Thus far the interactivity seemed to fit the ‘traditional’ concept. However, patterns that could be characterised as more ‘innovative’, with a more active student role, were found at the ‘traditional’ school as well. Similarly, even though the educational concept of the ‘innovative’ schools would suggest an active role for students in all respects, in most episodes a shared control of the content on the IWB was combined with operation of the board by the teacher. Therefore we conclude that although distinguishable patterns of interactivity characteristic for the two school types were found, the IWB-supported interactivity with regard to the active role of students was not always in line with what could be expected based on the schools’ educational concepts.

In the next two studies, Part II of this dissertation, our focus shifted to the integration of the developed technology use, i.e. the extent to which the developed technology use became an integral part of the classroom practices of the teachers involved in the studies. An indicator for technology integration that is often used is the quantity of use, like the number of computers available to students or the frequency with which
technology is used. In a quantitative assessment of ICT integration higher frequencies of use are generally associated with higher levels of integration (Mueller, Wood, Willoughby, Ross & Specht, 2008; Tondeur, Hermans, van Braak & Valcke, 2008). On the other hand we find studies that define ICT integration in a more qualitative way, focusing on the pedagogies that are being supported with technology. Some of these studies imply that technology can only be considered ‘integrated’ when it supports a specific type of teaching and learning, suggesting that the highest stage of technology integration is only found in a context of innovative, constructivist teaching and learning (Lim, 2007; Mueller et al., 2008; Sandholtz, Ringstaff, &Dwyer, 1997). A concept-guided approach to development of technology use calls for a more neutral qualitative definition that gives room to a variety of pedagogies (‘educational concepts’) in which technology use can be integrated. In the studies 3 and 4 we therefore chose to focus on the extent to which the teachers themselves perceived the technology as an integral part of their practices in our definition of integration. In order to describe the teachers’ perceptions three semi-structured focus group interviews were held at regular intervals with teachers at all five schools during the project. At two schools a fourth interview was held one year after the project had ended. The focus groups consisted of two to eight teachers per school, depending on how many teachers participated in the development and/or the realisation of the learning arrangements at the school.

From the studies in Part I we concluded that concept-guided development led to concept-specific differences in technology use. To explore whether concept-guided development of technology use might also lead to concept-specific differences in the integration of the developed technology we formulated the following research question for our third study (chapter 4): How can the achieved integration of technology in ‘traditional’ and ‘innovative’ schools that develop their use of technology in a concept-guided way be characterised in quantitative and qualitative terms?

In this study the integration of the developed technology use into the teachers’ classroom practices was studied at all five participating schools. For the quantitative characterisation of the integration we used descriptive data on all seventeen learning arrangements that were developed during the project. The results showed that the
‘traditional’ schools tended to use a smaller variety of ICT tools per learning arrangement than the ‘innovative’ schools. The numbers of computers per class (desktop and laptop) that were available across the learning arrangements did differ between the schools, but not between the school types. The number of learning arrangements that were abandoned or partly abandoned during the project differed somewhat between the school types, with slightly more learning arrangements being continued as designed at the ‘innovative’ schools. To qualitatively characterise the integrated technology use we looked at the perceived value of the technology use, as expressed by the teachers in the focus group interviews throughout the project. At all five schools the technology use in the learning arrangements that were continued was in general perceived as ‘common’ or ‘automatic’ and most of it also as ‘indispensable’. Both with regard to specific tools, like the IWB, and to technology in general, the teacher remarks indicated that at all schools at least some of the tools and their applications were highly valued by the participating teachers. In all five schools some of the newly introduced technology replaced the non-digital materials while other tools complemented existing materials or tools. These findings suggest that a concept-guided approach can promote the integration of technology use in schools with different educational concepts both in quantitative and in qualitative terms. The findings did not show clearly concept-specific differences in the achieved integration.

In order for innovations to lead to the intended effects they need to be sustained over a longer period of time (Jerald, 2005; Waslander, 2007). We therefore returned to one ‘traditional’ and one ‘innovative’ school one year after the project ended for an in-depth case study. For this fourth study (chapter 5) we formulated two research questions. First we investigated: Which of the technology use that was developed during the project was sustained, i.e. was still visible in the school? This aspect of sustainability was referred to as ‘longevity’. Secondly we investigated: Was the technology use developed further during the year after the project and if so: how? This aspect was referred to as ‘progressive integration’.

The final two focus group interviews at each of these two schools, held at the end of the project and one year after, were used to answer these questions. Both in terms of
longevity and progressive integration the technology use in the learning arrangements at the ‘innovative’ school appeared to be more sustainable than at the ‘traditional’ school. At the ‘traditional’ school one of the arrangements had been abandoned completely and in one of the partially sustained arrangements the abandoned element had not been replaced by other technology use. At the ‘innovative’ school no arrangements or elements of arrangements had been abandoned without being replaced by other technology use serving the same purpose and two learning arrangements were developed further, while at the ‘traditional’ school none of the technology use was developed further. At the ‘traditional’ school the teachers expressed no specific plans for future development of their technology use. At the ‘innovative’ school the teachers showed a tendency to continuously keep an eye open for ways to enhance their teaching and to incorporate technology therein. The further development of the technology use seemed to be part of the usual development of teaching and learning at this school.

**Discussion of the main results and conclusions**

In this section the theoretical and practical contributions of the dissertation are discussed, as well as limitations of the studies presented here. Also suggestions for further research are formulated.

**Theoretical contributions**

The results contribute to the existing theory on the development and integration of classroom use of ICT by providing findings that different types of schools can develop and integrate a type of ICT use that fits their educational concept, when applying the concept-guided approach. We developed analytical frameworks that enabled us to study the ICT use in detail. The first study analysed the developed ICT use in terms of the tools that are used, the activities in which they are used and the goals with which they are used. It enabled us to identify subtle differences between the different ways in which ICT is used. Similarly, in the analysis of the interactivity in lessons with the interactive whiteboard (IWB) in the second study the distinction between the aspects ‘operation of
the IWB’, ‘control of IWB content’ and ‘dialogue’, provided a detailed and nuanced picture of similarities and differences in the interactivity between schools with different school concepts. By providing these nuanced analyses of the developed ICT use in the context of different school concepts, these studies add to the findings from other studies that focus on the link between a school’s ICT use and educational concept (Ertmer, 2005; Hermans et al., 2008; Zhao et al., 2002).

In Part II the third and fourth studies contribute to the literature on ICT integration. The findings from both studies suggest that concept-guided development of technology use can lead to integrated technology use in schools with different educational concepts. This supports earlier findings that minimising the distance between technology innovation and the school’s educational practice promotes technology integration (Zhao et al., 2002) and the sustainability of this integration (Datnow, 2005; Jerald, 2005). The studies also showed that in cases where an innovation did not remain visible because it had been abandoned, it proved useful to also investigate why it was abandoned and whether it was replaced by something else that supported the initial goal of the innovation, i.e. whether the effort to innovate was sustained. Finally, the third study showed that the limited room for curriculum development by teachers in a strongly textbook-driven curriculum needs to be taken into account as a factor that may hinder progressive development of technology use in this type of school. In such a ‘traditional’ school with a strongly pre-structured curriculum there is little time and inducement for the teachers to take on the enterprise of continued development of a learning arrangement and of the professional development that is needed to do this (Huizinga, Handelzalts, Nieveen, & Voogt, 2014).

**Practical contributions**

Our conclusions provide schools with evidence that concept-guided development is a promising approach that can lead to ICT use that fits the school’s educational concept and can become sustainably integrated into the school’s educational practices. The studies in Part I particularly also provide schools and educational consultants with well-described examples of how the approach was carried out in five different schools and
the ICT use that was developed in the context of this particular project. The insights from both studies can help teachers and consultants to become more aware of the different meanings that seemingly similar goals for using technology may have in schools with different educational concepts. This can help teachers to make more conscious decisions about the goals they want to promote by using technology in their lessons, a skill that also needs to be addressed in teacher training courses (Tondeur, van Braak, Sang, Voogt, Fisser, & Ottenbreit-Leftwich, 2011; Uerz, Kral, & de Ries, 2014). Finally, the sustainable integration of the developed ICT use seems to be most likely to happen in schools where teachers have a more positive attitude towards the continued development of their ICT use. This implies that attention has to be paid to the innovative attitude of the teachers involved in the innovation which must in turn be understood in the context of the innovativeness of the school as a whole. Also, teachers need time to develop their own ICT use and to sustain this development. Providing teachers with this time may be a challenge especially for schools with a strongly textbook-driven curriculum.

Limitations and suggestions for further research

In all studies two to five schools participated. This relatively small scale gave us the opportunity to investigate in detail the learning arrangements that materialised at these schools as a result of concept-guided development of ICT use and their integration into the teachers’ classroom practices. Yet in order to verify these findings in the context of a larger number of schools with a wider range of educational concepts a more large-scale approach is needed. A limitation with regard to the sustainable integration of the developed technology use is that this was only studied in two of the participating schools and only from the teachers’ perspective. Sustainability of the integration of technology use that is developed in a concept-guided way requires attention in future studies with a larger scale and from different perspectives. An aspect that has not been investigated in these studies is the extent to which the developed technology use actually improved the quality of the teaching and learning processes that it supported. More research is needed to investigate this aspect of concept-guided development of
technology use, as improving teaching and learning is the main goal of technology innovation in the classroom. It would also be interesting to further investigate under which conditions concept-guided development of technology use promotes sustainable technology integration. Not all factors mentioned in the literature could be included in these studies, such as the teachers’ views and beliefs about technology at the outset of the project, possible tensions within the teams of teachers-as-designers and the role of the school leaders (Geijsel, Sleegers, Stoel, & Krüger, 2009; Huizinga et al., 2014; Thoonen, Sleegers, Oort, Peetsma, & Geijsel, 2011). Further research could provide more insight into these factors in the context of a concept-guided approach.

Finally, with regard to the ‘traditional’ school concept the limited room for curriculum development by teachers in a strongly textbook-driven curriculum needs to be paid attention to. In such a pre-structured curriculum there is little time for the teachers to take on the enterprise of continued development of a learning arrangement and of the professional development that is needed to do this. Future studies could shed a light on the challenge that concept-guided development of ICT use can pose in this type of school

**General conclusion**

In the four studies presented here we explored the technology use and its integration into teachers’ classroom practices that resulted from a concept-guided approach to the development of classroom technology use in five primary schools. The studies have shown that concept-guided development of technology use can lead to distinguishable types of technology use in schools with different educational concepts. The developed technology use became integrated into the teachers’ practices, although this integration was not necessarily sustainable. We therefore conclude that it is a promising approach that can help to realise the potential of classroom technology. Further research is needed to gain more insight into the conditions that promote the concept-guided development of sustainably integrated technology use, enabling schools to take full advantage of its benefits.
References


Mor, Y., & Mogilevsky, O. (2013). The learning design studio: collaborative design inquiry as teachers’ professional development. *Research in Learning Technology, 21*, 22054 - [http://dx.doi.org/10.3402/rlt.v21i0.22054](http://dx.doi.org/10.3402/rlt.v21i0.22054)


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Nederlandse samenvatting [Dutch summary]


Het overkoepelende doel van dit proefschrift was om te onderzoeken of conceptgeleide ontwikkeling van ICT-gebruik in scholen een bruikbare aanpak is om de integratie van ICT in het handelen van leerkrachten een impuls te geven. Steeds meer literatuur laat zien dat er een belangrijke relatie is tussen opvattingen over onderwijs en het gebruik en de integratie van ICT (Ertmer, 2005; Hermans, Tondeur, van Braak, & Valcke, 2008; Kim, Kim, Lee, Spector, & DeMeester, 2013; Liu, 2011; Zhao, Pugh, Sheldon, & Byers, 2002). Onderzoek toont aan dat een goede aansluiting tussen het onderwijsconcept van de school en het ICT-gebruik dat een school wil ontwikkelen een belangrijke factor is voor het succesvol integreren van ICT-gebruik. Volgens Zhao, Pugh, Sheldon and Byers (2002) geldt: hoe kleiner de afstand tussen de ICT-innovatie en de cultuur en praktijk van de school, hoe groter de kans dat het ICT-gebruik goed geïntegreerd raakt. Hoe en met welk effect ICT wordt gebruikt in scholen hangt af van de mate waarin de gebruikte ICT past in de bestaande handelingspatronen op de school (Tolmie, 2001). Dit lijkt samen te hangen met wat Niederhauser en Stoddart (2001)
vonden, namelijk dat leraren geneigd zijn om ICT in te zetten op een manier die aansluit bij hun persoonlijke visie op curriculum en instructie.

Conceptgeleide ontwikkeling van ICT-gebruik benut het mechanisme dat leraren geneigd zijn ICT te gebruiken op een manier die past bij hun didactisch handelen. In deze aanpak start ICT-innovatie vanuit het onderwijsconcept van de school door aan te sluiten bij de onderwijsopvattingen waarop de klassenpraktijken in de school gebaseerd zijn. Dit zou moeten bevorderen dat het ICT-gebruik ook daadwerkelijk geïntegreerd raakt in de praktijk van de school.

Het onderzoek dat hier wordt gepresenteerd is uitgevoerd in de context van het Cumulusproject. In dit project ondersteunden het APS, APS-IT diensten, Kennisnet en een team van onderzoekers van de Vrije Universiteit en de Hogeschool van Arnhem en Nijmegen een vijftal basisscholen bij het conceptgeleid ontwikkelen van ICT-gebruik. Twee van deze scholen hadden een zogenoemd ‘traditioneel’ onderwijsconcept: op deze scholen werd het onderwijs sterk bepaald door de gebruikte methodes en de leerkracht had een sterk sturende rol. De overige drie scholen hadden een zogenoemd ‘vernieuwend’ onderwijsconcept: op deze scholen werd het onderwijs meer vormgegeven rondom de interesses en leervragen van de kinderen en had de leerkracht een meer coachende rol.

De deelnemende scholen ontwikkelden gedurende twee schooljaren ieder maximaal vier ICT-rijke leerarrangementen op een conceptgeleide manier, zodat het ontwikkelde ICT-gebruik zou aansluiten bij hun onderwijsconcept. Een leerarrangement bevatte een plan voor een serie lessen en kon betrekking hebben op ieder schoolvak of combinaties van schoolvakken. Het ICT-gebruik in een leerarrangement kon variëren van het gebruik van oefensoftware op een computer tot het gebruik van een heel scala aan ICT-middelen in een onderzoekend-lerenproject. In totaal ontwikkelden de scholen in de loop van het project zeventien leerarrangementen.

De verwachting was dat de aansluiting van het ICT-gebruik bij het onderwijsconcept van de school een succesvolle integratie ervan zou bevorderen. We onderzochten het resulterende ICT-gebruik en de integratie daarvan in het handelen van de deelnemende leerkrachten. De overkoepelende onderzoeks vraag was:
In hoeverre draagt een conceptgeleide aanpak bij aan de ontwikkeling van ICT-gebruik dat geïntegreerd raakt in het handelen van leerkrachten op scholen met een ‘traditioneel’ of een ‘vernieuwend’ onderwijsconcept?

Om deze vraag te beantwoorden zijn er vier studies uitgevoerd. In deze samenvatting worden de belangrijkste bevindingen en conclusies uit deze studies besproken, alsmede implicaties voor theorie, praktijk en verder onderzoek. Tot slot wordt er een conclusie getrokken met betrekking tot de overkoepelende onderzoeksvraag.

Samenvatting van de belangrijkste bevindingen en conclusies

De twee studies in deel I van dit proefschrift waren gericht op het beschrijven van het ICT-gebruik dat voortkwam uit de conceptgeleide aanpak op de deelnemende scholen. ICT kan verschillende typen lesgeven en leren ondersteunen (Niederhauser & Stoddart, 2001; Higgins & Spitulnik, 2008; Inan, Lowther, Ross, & Strahl, 2010). Zowel individuele vormen van leren als samenwerkend leren en zowel leerlinggericht als leerkrachtgericht onderwijs kunnen met ICT worden ondersteund (Volman, 2005; Ten Brummelhuis & Kuiper, 2008). In de eerste studie (hoofdstuk 2) wilden we de volgende onderzoeksvraag beantwoorden: In hoeverre leidt conceptgeleide ontwikkeling van ICT-rijke leerarrangementen in basisscholen tot van elkaar te onderscheiden typen ICT-gebruik?

ICT-gebruik werd geoperationaliseerd in termen van de gebruikte middelen, de activiteiten waarin deze werden gebruikt en de doelen die de leerkrachten wilden bereiken met dit ICT-gebruik. De studie bestond uit casestudies van alle vijf scholen die deelnamen aan het project. De resultaten lieten zien dat de conceptgeleide aanpak inderdaad leidde tot duidelijk van elkaar te onderscheiden typen ICT-gebruik in de twee typen scholen. Op de ‘traditionele’ scholen werden doorgaans slechts één of twee verschillende ICT-middelen ingezet per leerarrangement; deze middelen ondersteunden vooral het gebruik van de methodes en de instructie door de leerkracht op deze scholen. De ICT-ondersteunde leeractiviteiten op deze scholen waren vooral gericht op het
vergroten van de betrokkenheid van de leerlingen bij de les en het uitbreiden van de mogelijkheden om vaardigheden te oefenen. In beperkte mate zetten deze scholen de ICT ook in om meer zelfstandig werken door leerlingen te bevorderen.

De leerarrangementen op de drie ‘vernieuwende’ scholen in het project werden gekenmerkt door het gebruik van een breed scala aan ICT-middelen die onderzoekende, open activiteiten ondersteunden en een aanzienlijke hoeveelheid input van de leerlingen mogelijk maakten. Op één school speelden visuele middelen een belangrijke rol, op de andere twee scholen het internet en andere middelen die onderzoeksactiviteiten ondersteunen.

Op grond van deze bevindingen concluderen we dat de ICT-middelen, activiteiten en doelen de twee onderwijsconcepten weerspiegelden die de scholen van elkaar onderscheidden. De studie liet daarnaast zien dat de ‘traditionele’ scholen minder complex ICT-gebruik ontwikkelden, dat relatief gemakkelijk te implementeren was, terwijl de ‘vernieuwende’ scholen complexer ICT-gebruik ontwikkelden en meer moeite hadden met de implementatie. Dit punt is verder onderzocht in de derde en vierde studie.

Eerst zoomden we in de tweede studie (hoofdstuk 3) verder in op het interactieve gebruik van het digitale schoolbord. Beide schooltypen gebruikten dit middel, zoals de eerste studie liet zien. Een onderscheid tussen de schooltypen was de mate waarin leerlingen een actieve rol kregen toegewezen in hun leerproces. We verwachten dat dit onderscheid ook terug te zien zou zijn in het interactieve gebruik van het digitale bord. Dit leidde tot de volgende onderzoeksvraag: Welke typen interactiviteit ondersteunt het digitale schoolbord in ‘traditionele’ en ‘vernieuwende’ scholen die hun ICT-gebruik conceptgeleid ontwikkelen?

Daartoe is in deze studie het interactieve gebruik van het digitale bord in twee ‘traditionele’ en twee ‘vernieuwende’ scholen onderzocht. Van drie lessen per schooltype zijn video-observaties geanalyseerd. De studie richtte zich op interacties tussen leerkracht, leerlingen en het digitale bord in klassikale lessen. Dit soort interacties kwam namelijk het meeste voor in de geobserveerde lessen met het digitale bord. In de analyse werd onderscheid gemaakt tussen de bediening van het bord, de controle over de inhoud op het bord en het type dialoog rondom het gebruik van het bord.

In de lessen op de ‘traditionele’ scholen zagen we in de meeste geanalyseerde fragmenten de leerkracht het bord bedienen en de inhoud op het bord bepalen. Dit ging in de meeste gevallen samen met een dialoog die gericht was op kennisoverdracht. Maar ook meer ‘vernieuwende’ interactiepatronen kwamen voor, met een meer actieve rol voor de leerling. Op de ‘vernieuwende’ scholen had de leerling in de meeste fragmenten weliswaar een meer actieve rol als het ging om de inhoud op het bord, maar was de leerkracht meestal degene die het bord bediende. De dialoog was in de meeste gevallen
gericht op kennisconstructie. We concluderen daarom dat er in de lessen met het digitale bord weliswaar interactiepatronen te zien waren die passen bij het onderwijsconcept van de school, maar dat met name de rol van de leerling niet altijd overeen kwam met wat op basis van het onderwijsconcept van de school te verwachten was.


Om deze integratie te beschrijven hielden we in de loop van het project op alle vijf de scholen drie focusgroepinterviews met leerkrachten die betrokken waren bij het project. Op twee scholen, een ‘traditionele’ school en een ‘vernieuwende’ school, werd een jaar na afloop van het project nog een vierde interview gehouden. De focusgroepen bestonden uit twee tot acht leerkrachten per school, afhankelijk van het aantal leerkrachten dat op de school betrokken was bij het ontwikkelen en/of uitvoeren van de leerarrangementen.
Uit de studies in deel I concludeerden we dat conceptgeleide ontwikkeling leidde tot conceptspecifieke verschillen in ICT-gebruik. Om te onderzoeken of deze aanpak ook zou leiden tot conceptspecifieke verschillen in de integratie van het ontwikkelde ICT-gebruik formuleerden we de volgende onderzoeksvraag voor de derde studie (hoofdstuk 4): Hoe kan de bereikte integratie van ICT-gebruik in ‘traditionele’ en ‘vernieuwende’ scholen die hun ICT-gebruik conceptgeleid ontwikkelen gekarakteriseerd worden in kwantitatieve en in kwalitatieve termen?

In deze studie onderzochten we de integratie van het ontwikkelde ICT-gebruik in het handelen van de deelnemende leerkrachten in de vijf scholen. Voor de kwantitatieve meting van de integratie maakten we gebruik van beschrijvende data over alle zeventien gerealiseerde leerarrangementen. De resultaten laten in de ‘traditionele’ scholen een kleinere variatie aan ICT-middelen per leerarrangement zien dan in de ‘vernieuwende’ scholen. Het aantal computers dat per klas beschikbaar was voor de verschillende leerarrangementen verschilde wel per school, maar niet per schooltype. Op de ‘traditionele’ scholen werden iets meer leerarrangementen beëindigd of gedeeltelijk beëindigd voor het einde van het project. Voor de kwalitatieve meting van de integratie keken we naar de ervaren waarde van het ICT-gebruik, zoals uitgedrukt door de leerkrachten in de focusgroepinterviews gedurende het project. Op alle vijf de scholen werd het meeste ICT-gebruik in de leerarrangementen over het algemeen ervaren als ‘gewoon’ of ‘vanzelfsprekend’ en vaak ook als ‘onmisbaar’. Dit had zowel betrekking op specifieke middelen, zoals het digitale schoolbord, als op het ICT-gebruik in het algemeen. In alle vijf de scholen verving een deel van de nieuwe ICT-middelen bestaande materialen, terwijl andere ICT-middelen een toevoeging waren op de bestaande materialen en middelen.

Deze bevindingen duiden erop dat de conceptgeleide aanpak zowel in kwantitatieve als in kwalitatieve termen ICT-integratie in het handelen van de leerkracht kan bevorderen in scholen met verschillende onderwijsconcepten. Er kwamen uit deze studie geen duidelijke conceptspecifieke verschillen in integratie naar voren.

Om van een innovatie te kunnen spreken, moet deze over een langere periode worden voortgezet (Jerald, 2005; Waslander, 2007). Daarom zijn we een jaar na afloop van het
project teruggegaan naar een ‘traditionele’ en een ‘vernieuwende’ school voor een laatste focusgroepinterview. Voor de vierde studie (hoofdstuk 5) formuleerden we twee onderzoeksvragen. Eerst onderzochten we: Welk ICT-gebruik dat tijdens het project werd ontwikkeld was nog zichtbaar in de school? Dit aspect van duurzame integratie duidden we aan met de term ‘longevity’. Daarna onderzochten we of het ICT-gebruik verder werd ontwikkeld in het jaar na afloop van het project en zo ja: hoe. Dit aspect duidden we aan als ‘progressieve integratie’.

Uit de focusgroepinterviews kwam naar voren dat in termen van zowel ‘longevity’ als progressieve integratie het ICT-gebruik in de leerarrangementen op de ‘vernieuwende’ school meer duurzaam was dan op de ‘traditionele’ school. Op de ‘traditionele’ school was één leerarrangement helemaal beëindigd en in een arrangement dat gedeeltelijk was beëindigd was het verdwenen element niet vervangen door iets nieuws. Op de ‘vernieuwende’ school waren geen leerarrangementen geheel of gedeeltelijk beëindigd zonder dat er nieuw ICT-gebruik voor in de plaats kwam. Op deze school waren bovendien wel leerarrangementen verder ontwikkeld, terwijl dit op de ‘traditionele’ school niet was gebeurd. Op de ‘traditionele’ school gaven de leerkrachten ook niet aan dat zij specifieke plannen hadden om hun ICT-gebruik verder te ontwikkelen. Op de ‘vernieuwende’ school hadden de leerkrachten de neiging om voortdurend te zoeken naar nieuwe manieren om hun onderwijs te verbeteren met behulp van ICT. De verdere ontwikkeling van het ICT-gebruik leek op deze school een integraal onderdeel te zijn van de onderwijsontwikkeling.

**Reflectie op de bevindingen en conclusies**

In deze paragraaf bespreken we de theoretische en praktische betekenis van de studies in dit proefschrift, alsook de beperkingen ervan en suggesties voor verder onderzoek.

*Theoretische bijdragen*

De besproken onderzoeksresultaten dragen op verschillende manieren bij aan de bestaande theorie over de ontwikkeling en integratie van ICT-gebruik in de klas. De
studies laten zien dat conceptgeleide ontwikkeling van ICT-gebruik in scholen met verschillende onderwijsconcepten kan leiden tot de ontwikkeling van duidelijk te onderscheiden typen ICT-gebruik. We ontwikkelden daartoe analysemodellen die het mogelijk maakten om het op de scholen ontwikkelde ICT-gebruik in detail te bestuderen. De analyse van het ICT-gebruik in termen van middelen, activiteiten en doelen in de eerste studie maakte het mogelijk om subtiele verschillen te identificeren in de manieren waarop ICT wordt toegepast in de verschillende schooltypen. Op vergelijkbare wijze gaf de tweede studie een gedetailleerd beeld van verschillen in de interacties rondom het digitale bord door onderscheid te maken tussen verschillende aspecten van interactiviteit: de bediening van het bord, de controle over de inhoud op het bord en de dialogen in de klas. Deze analysemodellen dragen zo bij aan een beter begrip van de relatie tussen onderwijsconcept en ICT-gebruik (Ertmer, 2005; Hermans et al., 2008; Zhao et al., 2002).

De studies in deel II dragen op hun beurt vooral bij aan de literatuur over de integratie van ICT-gebruik. De bevindingen van de derde en vierde studie suggereren dat de conceptgeleide aanpak inderdaad kan leiden tot geïntegreerd ICT-gebruik in scholen met verschillende concepten. Dit ondersteunt eerdere bevindingen dat een ICT-innovatie meer kans van slagen heeft als deze aansluit bij het onderwijsconcept van de school; dit bevordert dat het ICT-gebruik geïntegreerd raakt (Zhao et al., 2002) en dat de integratie ook duurzaam is (Datnow, 2005; Jerald, 2005). Wanneer een bepaalde vorm van ICT-gebruik wordt beëindigd, blijkt het zinvol te zijn om ook te onderzoeken waarom dat het geval is en of deze is vervangen door iets waarmee hetzelfde doel wordt nagestreefd. Dan wordt niet meer alleen onderzocht of een specifieke innovatie duurzaam geïntegreerd raakt, maar ook of de intentie om te innoveren duurzaam blijkt te zijn. Tot slot liet de derde studie zien dat de beperkte bewegingsvrijheid die leerkrachten in een sterk methodegestuurd curriculum hebben een factor is die de progressieve integratie van ICT-gebruik kan beperken. In een ‘traditionele’ school met een sterk voorgestructureerd curriculum is er weinig tijd en ruimte voor de leerkrachten om leerarrangementen verder te ontwikkelen en voor de professionele ontwikkeling die dat van hen vraagt (Huizinga, Handelzalts, Nieveen, & Voogt, 2014).
Implicaties voor de onderwijspraktijk

De vier uitgevoerde studies hebben verschillende implicaties voor de onderwijspraktijk. Onze conclusies laten zien dat conceptgeleide ontwikkeling een veelbelovende aanpak is voor het ontwikkelen en integreren van concept-specifiek ICT-gebruik. Met name de studies in deel I bieden gedetailleerde voorbeelden van hoe deze aanpak eruit kan zien en wat voor concept-specifieke vormen van ICT-gebruik deze kan opleveren. De verschillende manieren waarop op het eerste gezicht vergelijkbare doelen met ICT-gebruik kunnen worden ingevuld, afhankelijk van de achterliggende onderwijsvisie, zijn belangrijk om in het oog te houden wanneer ICT-ondersteunde leeractiviteiten worden ontworpen. Dit kan leerkrachten helpen meer bewuste keuzes te maken in de doelen die ze met hun ICT-gebruik willen nastreven en de manier waarop ze dat willen gaan doen. Dit is een aspect dat ook aandacht vereist in de lerarenopleidingen (Tondeur, van Braak, Sang, Voogt, Fisser, & Ottenbreit-Leftwich, 2011; Uerz, Kral, & de Ries, 2014).

Tot slot bevestigen de studies dat een positieve houding van de betrokken leerkrachten ten opzichte van onderwijsinnovatie van belang van is voor het verder ontwikkelen van hun ICT-gebruik. Dit houdt in dat er in een innovatietraject ook aandacht nodig is voor de innovatieve houding van leerkrachten. Bovendien hebben leerkrachten tijd nodig om hun ICT-gebruik te kunnen blijven ontwikkelen. Dit kan met name voor scholen met een ‘traditioneel’ onderwijsconcept een uitdaging zijn.

Beperkingen en suggesties voor verder onderzoek

In alle vier de studies onderzochten we maximaal vijf scholen. Deze relatief kleine schaal gaf ons de gelegenheid om de ontwikkelde leerarrangementen en hun integratie in het handelen van de leerkrachten in detail te bestuderen. Echter, om deze bevindingen te verifiëren en te kunnen generaliseren zijn grootschaliger studies nodig met een groter aantal scholen en een grotere variatie in onderwijsconcepten. Met betrekking tot de duurzame integratie is een beperking dat we deze maar op twee scholen hebben onderzocht en alleen hebben gemeten vanuit het perspectief van de leerkracht. Dit aspect van integratie van ICT-gebruik dat conceptgeleid is ontwikkeld verdient ook
zeker aandacht in grootschaliger vervolgonderzoek, waarbij dan ook vanuit andere perspectieven wordt gekeken. Verder is in deze studies niet gekeken naar de kwaliteit van het ontwikkelde ICT-rijke onderwijs. Meer onderzoek is nodig om te onderzoeken in hoeverre conceptgeleid ontwikkeld ICT-gebruik daadwerkelijk de onderwijspraktijk en uiteindelijk ook de leerprocessen en -resultaten van leerlingen op de betrokken scholen verbetert. Ook is het de moeite waard om nader te onderzoeken onder welke omstandigheden een conceptgeleide aanpak leidt tot duurzaam geïntegreerd ICT-gebruik. Niet alle factoren die van invloed zijn op het verloop van een innovatie konden worden meegenomen in deze studies, zoals de visie en overtuigingen van leerkrachten voorafgaand aan hun deelname aan het project, mogelijke spanningen binnen de leerkrachtenteams en de rol van de schoolleiders (Geijsel, Sleegers, Stoel, & Krüger, 2009; Huizinga et al., 2014; Thoonen, Sleegers, Oort, Peetsma, & Geijsel, 2011). Nader onderzoek is daarom nodig om ook aan deze factoren aandacht te besteden in de context van conceptgeleide ontwikkeling van ICT-gebruik. Tot slot vergt op scholen met een traditioneel onderwijsconcept de beperkte ruimte van leerkrachten voor onderwijsontwikkeling aandacht in vervolgstudies. Het is de moeite waard om nader onderzoek te richten op de uitdaging die conceptgeleide ontwikkeling van ICT-gebruik voor dit type scholen betekent.

Algemene conclusie

In de vier hier gepresenteerde studies onderzochten we het ICT-gebruik dat conceptgeleid werd ontwikkeld op vijf basisscholen en de integratie hiervan in het handelen van de betrokken leerkrachten. De studies hebben laten zien dat conceptgeleide ontwikkeling van ICT-gebruik op scholen kan leiden tot ICT-gebruik dat duidelijk varieert, afhankelijk van het onderwijsconcept van de school. Deze aanpak droeg er op de onderzochte scholen bovendien aan bij dat dit ICT-gebruik geïntegreerd raakte in het handelen van de betrokken leerkrachten, hoewel dit niet per definitie een duurzame integratie bleek te zijn. We concluderen daarom dat dit een veelbelovende aanpak is die kan helpen om de kloof te overbruggen tussen de belofte van ICT voor het onderwijs en de realisatie hiervan in de praktijk. Nader onderzoek is nodig om meer
zicht te krijgen in de condities die bijdragen aan duurzame integratie van ICT-gebruik op verschillende typen scholen, en hoe scholen hierbij maximaal profijt kunnen hebben van conceptgeleide ontwikkeling van ICT-gebruik.
Papers in this dissertation and contributions of co-authors

Chapter 2

Chapter 2 is based on the article:

Contributions

Sandra de Koster is the first author of this paper. Monique Volman and Els Kuiper were the supervisors of Sandra de Koster. Monique Volman and Marijke Kral designed the practice-oriented research project on which the study is based. The three authors and researchers Marijke Kral, Bregje de Vries, Marieke de Visser and Ronald Kok and Marijn Tanis collected the data. The authors collaboratively conceptualised and designed the study. As a form of audit, they discussed all the steps in the process of analysis and its outcomes. The supervisors contributed to the analysis and interpretation of the data, and reviewed and revised the manuscript.

Chapter 3

Chapter 3 is based on the article:
Contributions

Sandra de Koster is the first author of this paper. Monique Volman and Els Kuiper were the supervisors of Sandra de Koster. Monique Volman and Marijke Kral designed the practice-oriented research project on which the study is based. The three authors and researcher Marijn Tanis, collected the data. The authors collaboratively conceptualised and designed the study. As a form of audit, they discussed all the steps in the process of analysis and its outcomes. The supervisors contributed to the analysis and interpretation of the data, and reviewed and revised the manuscript.

Chapter 4

Chapter 4 is based on the article:


Contributions

Sandra de Koster is the first author of this paper. Monique Volman and Els Kuiper were the supervisors of Sandra de Koster. Sandra de Koster and researcher Marijn Tanis collected the data. The authors collaboratively conceptualised and designed the study. As a form of audit, they discussed all the steps in the process of analysis and its outcomes. The supervisors contributed to the analysis and interpretation of the data, and reviewed and revised the manuscript.

Chapter 5

Chapter 5 is based on the article:

de Koster, S., Kuiper, E., & Volman, M. (in revision). Sustainability of technology integration in the classroom in a ‘traditional’ and an ‘innovative’ school.
Contributions

Sandra de Koster is the first author of this paper. Monique Volman and Els Kuiper were the supervisors of Sandra de Koster. Sandra de Koster and researcher Marijn Tanis, collected the data. The authors collaboratively conceptualised and designed the study. As a form of audit, they discussed all the steps in the process of analysis and its outcomes. The supervisors contributed to the analysis and interpretation of the data, and reviewed and revised the manuscript.
About the author

Sandra de Koster was born on 5 October 1970 in Venray, the Netherlands. She obtained her pre-academic degree at the Boschveld College in Venray in 1989. After having obtained a professional degree in Juvenile Work in Groningen in 1994 she had various jobs, among others as a juvenile worker at the Dutch Child Protection Services, as an editor at an educational publishing firm and as a childcare worker in various childcare centres. She later studied Educational Sciences at the University of Amsterdam and at VU University in Amsterdam and in 2007 graduated cum laude from the master of Educational Sciences at VU University in Amsterdam. After finishing her studies she started working on the Cumulus project as a PhD candidate at VU University. In 2009 she organised the symposium ‘Exploring the link between educational views and the use of ICT in the classroom’ for the 13th Biennial Conference for Research on Learning and Instruction (Earli) that was held at VU University. In 2010 she moved to the University of Amsterdam together with promotor Monique Volman and co-promotor Els Kuiper. After her employment at the University of Amsterdam she moved back to Venray and started teaching research skills and supervising graduating students in higher education. While attending a teacher training course at HAN University of Applied Sciences in Nijmegen she worked as an English teacher in secondary education. She is currently working as an independent writer and thesis supervisor. Her research interests include the integration of educational technology, educational innovations in general, teacher professional development and professional learning communities in the context of educational change.
List of publications

Peer-reviewed publications


Papers in progress

de Koster, S., Kuiper, E., & Volman, M. (in revision). Sustainability of technology integration in the classroom in a ‘traditional’ and an ‘innovative’ school.

Conference contributions


De Koster, S., Kuiper, E., & Volman, M. (2011). *Interactiviteit rond het digibord in de context van conceptgeleide ontwikkeling van ICT-gebruik: Welke typen interactiviteit ondersteunt het digibord op traditionele en vernieuwende scholen?* [Interactivity surrounding the interactive whiteboard in the context of concept-guided development of ICT use: which types of interactivity does the interactive whiteboard support in traditional and innovative schools?] Roundtable session at Onderwijs Research Dagen (ORD) 2011, Maastricht, the Netherlands.


**Other publications**

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