1. Digital Literacy and Subject Matter Learning

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Abstract: It is generally agreed that learners need to acquire digital literacy in order to act as competent citizens, employees and entrepreneurs in a digitalised environment. It is also generally agreed that digital literacy is the responsibility of educational systems that are themselves increasingly digitalised. Studies show that while students' digital production is a powerful driver for learning, a lack of digital literacy among teachers and students is an equally powerful barrier. There is no shared conception, however, of the meaning of digital literacy that may mean both *bildung* (general education) and a wide range of specific skills and competences: from basic computer skills, to source criticism and multimodal analysis, to social norms in online environments. Therefore, learning designs that are aimed at learners' acquisition of digital literacy, including related learning objectives, appear to be what Feltovich and colleagues call *ill-structured* (1996). In this paper, we present approaches that are embedded into everyday school practise and combine the acquisition of digital literacy as both *bildung* and a set of specific competencies. Accordingly, digital literacy need not necessarily be a course on the curriculum. These approaches rest on findings stemming from a large ongoing project within Danish primary and lower secondary schools, in which students worked with digital production of subjects and cross-disciplinary learning objects that were aimed at other students. These learning designs appeared to produce arenas in which students challenged and developed their digital literacy. The empirical data were produced through a mixed-methods approach whereby action research—one of the mixed methods—was combined with a series of interventions that supported iterative improvements to (and changes in) the learning designs and practise throughout the project's life cycle. The findings thus far are that digital production facilitates students' learning processes and qualifies their learning results in both digital and subject matter literacy when executed within a teacher-designed framework that empowers student agency. At present, the project's findings and practises are being implemented in the participating schools and at teacher educations. Because the findings are published elsewhere (together with a presentation of our learning design theory and research methodology), this paper emphasises the theoretical side of the suggested approaches based on Allan Martin's conceptual model of digital literacy, which we expand with Manuel Castells' *self-programmable* individual and Margaret Boden's concept of creativity. To conclude, we point to areas of interest for future development and research in the field.

Keywords: digital literacy, design for learning, learning objectives, *bildung*, general education, mixed methods.

1. Introduction

Since the 2000s, information and communication technology (ICT) has been integrated into children's everyday lives even before they start school. Between 2005 and 2010, the average starting age for Internet use has dropped from nine to four years (Medierådet, Sweden 2010). In the same period, more than 25% of nine- and ten-year-olds had a social media profile (Medierådet for Børn og Unge, Denmark 2009), and as soon as children are capable of transforming their multimodal reading and writing competencies into agency on the Internet, they create profiles on one or more social media platforms (Ibid). In general, children are drawn to ICT, and they find it fun (Plowman and Stephen 2005; Beschorner and Hutchison 2013); at present, we see children in early pre-school playing with iPads and smartphones while they effortlessly redefine the predesigned affordances of apps to their own liking (Kjällander and Moinian 2014). Although concerns have been documented about children's online whereabouts and the possible dangers of the Internet (Livingstone et al. 2014), parents are, according to Guðmundsdóttir and Hardersen (2012) and Moinian (2011), in general positive towards children's use of digital devices because of the learning potential. This viewpoint is shared by many pre-school teachers (Sandvik, Smørdal and Østerud, 2012; Aesaert et al. 2015), and the implementation of ICT in kindergartens is often justified from a learning perspective (Hundeland, Carlsen and Erfjord 2014; Mercer 2014; Praet and Desoete 2014; Zaranis 2014). Due to their early exposure to ICT and their familiarity with the various technologies, many children possess basic digital user competencies by the time they begin school. Schools can advantageously build upon and exploit these competences as a driver for learning.

However, children's way of relating to digital media and the learning potential of digital media as such is not the only reasons that ICT should be part of everyday school practise. Although reading, writing and calculating were once the three core competencies on which primary schools built all teaching, these are no longer sufficient in our twenty-first-century networked society. They have been expanded to encompass additional core competencies regarding information, media and ICT, into what the OECD calls 'twenty-first-century skills' (OECD 2008; Ananiadou and Claro 2009). At present, information, media and ICT-related skills and competencies are recognised to be among the key competencies in order to become competent participants in education, work life, culture and civil society in general. These competencies are often addressed together as the convergent concept of *digital literacy*. The transformation of children's informally acquired digital competencies into digital literacy cannot be left to the students alone. Schools have an obligation to society to qualify students' learning and to consolidate their digital literacy.

Digitally experienced children provide their schools with competency-based opportunities; on the other hand, they also bring about challenges, as there is no direct line from digital experience to digital literacy. While some students master the development of their digital competencies and their knowledge of digital options as their curiosity drives them to explore and play with digital devices and apps, this does not apply to all children and youth (Schultz Hansen 2015; Bundsgaard, Pettersson and Puck 2014; Levinsen, Ejsing-Duun and Sørensen 2013; Levinsen and Ørngreen 2012; Kim and Lee 2013; Thomas 2011; Plowman, Stephen and McPake 2010). Many children who appear to be digitally competent only possess basic ICT competencies that allow them to use digital resources: for example, watching YouTube, sharing content through social media, playing games or shopping. They are not able to construct or edit multimodal elements, perform searches with more than one search word, understand the importance of source criticism, etc. This means that they are vulnerable both as learners in the school and in their everyday lives, especially if they encounter new digital resources, or the resources they are familiar with suddenly change in radical ways.

Our approach to *digital literacy* is that it is an ongoing, lifelong learning process. In line with this view, we suggest approaches that allow teachers and students to develop and consolidate their *digital literacy* as *bildung* (general education), competencies and skills*,* without necessarily having *digital literacy* as a specific subject in the curriculum.

2. Literature study

Being a digital native is not the same as being *digitally literate.* The responsibility for education in the twenty-first century is a serious matter, and society cannot leave it to the children to transform their own digital experiences into digital literacy (Sørensen and Levinsen 2014a; Turbill and Murray 2006). It is society's educational responsibility to ensure that all students acquire digital literacy. Therefore, ICT should be ubiquitous and accessible to students at all school levels as early as possible.

This demand challenges schools, teachers and teacher education programmes (in terms of their educational approach and learning designs) to find new ways of producing arenas where students can qualify, embed and transform their digital experiences into digital literacy (Kereluik et al. 2013). The research and knowledge of how students acquire digital literacy or transform their digital experiences into digital literacy remains scarce, however. In his foreword to the book *Deconstructing Digital Natives* (Thomas 2011, p. x), David Buckingham argues that digital natives are rather mundane in their use of digital resources and display routine rather than innovative and creative behaviour. In addition, in her book *The University of Google*, Brabazon (2007) points to stunning contradictions between the expected and actual digital competencies and skills of learners in the digital age. An extensive literature review of empirical studies conducted by Jones (2012) finds that among students who are naturally proficient with technology (from exposure to a technology-rich environment), not all were equally competent with technologies, and their patterns of use vary considerably when moving beyond basic technologies. These findings correspond with a large-scale study on the ICT literacy levels of 15,558 South Korean middle-school students. The study found that the highest percentage of students (57.7%) mastered the basic level, and the next-highest percentage (31.4%) mastered the average level; the excellent and below basic level students were represented by 6.3% and 4.5% respectively (Kim and Lee 2013). A similar Danish study (Levinsen and Ørngreen 2012) analysed the digital literacy of 183 students aged 15–24. In a survey, the students were asked to self-evaluate themselves as *novice, average* or *advanced* in relation to the questions *How good am I at performing specific tasks?* and *How good am I at dealing with unknown digital resources?* The survey was followed by focus group interviews that went into detail on the students' ICT use. In both datasets, the informants reported their use of ICT as dominated by consumption, file sharing,

communication and e-shopping, which are relatively simple interactions at the basic to average level. This study concluded that even though the students reported a wide and routinised repertoire of uses, this did not correspond with an advanced level in which they were able to transform digital *experience* into digital *literacy* or to deal with radical changes in their digital environment. In addition, the above refereed literature documents that in relation to learning, teachers' and students' lack of digital literacy magnifies technological challenges and break-downs at the cost of learning. As a result, in increasingly digitalised schools, digital literacy becomes an indispensable precondition for learning.

Taking our starting point as the fact that digital literacy does *not* emerge spontaneously, but rather has to be facilitated, in this paper we present approaches to acquiring digital literacy that are embedded into everyday school practises. These approaches combine *bildung* and specific competences, learning objectives and criteria for evaluating progression. Before presenting the approaches, we briefly introduce the empirical study and the findings that have inspired the operationalisation of the approaches as practises, followed by a presentation of the theoretical framework that forms the basis for these approaches.

3. The project methodology and findings

The project *Students' Digital Production and Students as Learning Designers* (2013–2015) is a large-scale continuation of an earlier project (Sørensen and Levinsen 2014a) that is funded by the Danish Ministry of Education; the project will run to the end of 2015. The project is conducted by a consortium of two universities, three university colleges and the LEGO foundation, and follows interventions over 1½ years in the first/second and fifth/sixth grades at four schools and two cohorts at a Ten-Grade Centre. At each school, one class from each level is followed intensively while the parallel classes are followed extensively. Thirteen researchers and approximately 30 teachers and 750 students participate; the schools were chosen from a pool of candidates to meet geographical and socio-economic dispersion requirements. The interventions are designed as frames with increasing complexity, from simple exercises to transdisciplinary activities that involve advanced technologies (e.g. social media, robotics or location-based technologies). In accordance with action research, the researchers and teachers collaborate closely to adapt the frames locally, as the interventions must be integrated into the school year.

The project is complex, and produces data using two main approaches within an overall mixed-methods framework (Levinsen et al. 2014: 1). Baseline measures are conducted as a long-term diachronic quantitative survey combined with qualitative structured observations. Each of the six interventions is followed through synchronic and diachronic approaches, where the researchers (as action researchers) follow the interventions. The qualitative data are collected as observations, semi-structured individual and focus group interviews, informal conversations with teachers and students, video-recordings, photos and artefacts. The aim is to produce a complementary set of data that will record and document the interventions and will allow for analyses of their impact on the students' learning and the teachers' practise.

The empirical data are currently processed using *Atlas.ti* for analysis; as such, the presented findings are preliminary. The following examples are from a second grade class where the project's emerging learning design has been successfully implemented and the students work as learning designers of digital productions aimed at other students within a teacher-based frame that encourages student agency and emphasises evaluation as a learning practise (Levinsen and Sørensen 2015). The examples show how the class and their teacher deal with digital challenges and acquire digital literacy:

- Thomas, a mathematically gifted student, uses the 'Math Professor' app to solve problems that are too easy for his level. The teacher asks: 'Do you know how to make them more difficult?' Thomas answers, 'Yes, but I can't remember how'. 'Why don't you find out and tell the others?' Thomas searches through the settings, and experiments with various options. 'It's the one with the sliders—you set the slides and then you calculate with the numbers between *Min.* and *Max'.*
- One group discovers that some of their video takes have accidently been deleted. In accordance with the class-principle of '*Ask a child before a grown-up',* they ask Malene, who is one of the class-experts. She knows the iPad-feature '*recently deleted'* and demonstrates to the group how they can retrieve their missing videos. Malene uses the class-principle '*Help others to do it themselves'.*
- In another group, there is no more space left on Mary's iPad and they are unable to save their video-takes. They look at the feature '*used'* under '*cogwheel'* (the iPad-settings) and conclude that they have to remove many large files, and that not all of them can be deleted. The teacher gives the group

the task: 'Find out where Mary can store her files. And remember to prepare instructions for the rest of us'. The class-expert Sophie helps them to identify apps that can be temporarily deleted.

- The teacher asks Tom and Jack if they know iMovie: 'We do, but we can't use it'. The teacher asks Josephine: 'Do you want to instruct them?'. Josephine accepts, and Frida from another group asks: 'Can I go too? Because … I am not good at iMovie'. The teacher forms an ad hoc-group with the task: 'Make a small dummy-movie—film, clip, edit—that's how to learn iMovie'.
- Parsley and Olivia have explored iMovie at home. Parsley explains that the app contains templates in various genres where people can make movie trailers or full movies: horror, spy movies, romances, etc. The students have produced a trailer for their own horror movie, 'The Girl in the Basement', with Olivia's five-year-old brother as the cameraman. The teacher asks the class to think about what they can learn from the trailer while they watch it. The class articulates a multimodal analysis of the students' choices of camera angles and distance, image composition, editing, light-setting, acting and props. Then the class, facilitated by the teacher, formulates several learning objectives and evaluation criteria for their next production. The objectives and criteria are uploaded to the shared network.

These examples demonstrate two important issues: 1) there is synergy between the students' subject-related work and their acquisition of digital literacy; 2) the synergy does not always emerge spontaneously. We find that the class-culture and practises facilitate the synergy in terms of the teacher, who prompts the students to explore the technology and to reflect upon and articulate the challenges and instructions regarding ICT as technology and as a multimodal means of expression. The teacher uses these strategies to identify class-experts and to ground the class-principles *'Ask a child before a grown-up'* and *'Help others to do it themselves'*. We therefore suggest the project's learning designs as a suitable arena for facilitating the transformation from digital experiences into digital literacy. This means that teachers must be equally aware of ICT, the learning design categories (objectives, content, planning and organisation, and evaluation), and classroom practises. As these examples demonstrate, the transformation from digital experience to digital literacy is facilitated when the role and agency of ICT becomes the objective of conscious reflection and action.

4. Theoretical framework

As mentioned earlier, digital literacy has many meanings and appears to be *ill-structured*. We have chosen Martin's (2006) interpretation of digital literacy, as it combines specific digitally related competencies with *bildung*. We expand Martin's digital literacy–perspective with Castells' general literacy or *bildung*-perspective of the *self-programmable* person who meets challenges in informal ways and who collaborates when new knowledge and competences are needed in order to cope with an ever-changing environment (Castells 2000). The *self-programmable* person breaks with *downloading*, which is the habitual practise of repeating previous experiences and routines (Hildebrandt et al. 2012). In relation to our suggested approaches to acquiring digital literacy, we look to Martin's and Castells' work as the providers of learning objectives. Achieving these learning objectives demands creativity, which is also a twenty-first-century competency (EU-Commission 2006). As neither creativity nor digital literacy always emerge spontaneously, however, but have to be facilitated, we use Boden's (1990) work as the provider of a learning design-frame, as Boden defines creativity as the ability to generate new and valuable ideas, as well as offers practises that invite creativity.

According to Martin (2006), *digital literacy* is the lifelong learning of capabilities for functioning in our digitalised twenty-first-century reality, which includes three interdependent levels of engagement (p. 155):

- *Digital competence* is the foundation; it consists of knowledge, understandings, attitudes and skills related to digital media. Individuals draw upon digital competences when needed, and develop them as new challenges arise.
- A corpus of *digital usages* is the central and most crucial level; this represents the digital competences that allow the application of ICT within professional contexts and specific domains (e.g. the school). Thus, digital usages form part of a community's culture and are generated as a mixture of domain-specific, organisational and personal/professional development.
- *Digital transformation* is the uppermost level; it is achieved when the corpus of digital usages enables innovation and creativity and stimulates radical changes within a professional or knowledge domain. Transformation may happen at the individual, group or organisational level.

Martin's three levels of engagement relate specifically to digital literacy, but they correspond with Castells' general competencies that need to be included: becoming *self-programmable* and being able to break with

downloading. If students are to achieve these goals, then learning designs need to challenge them to take control of their competence building. We have found in this project that students are able to take control of their learning and competence building and to act *self-programmable* within the initial (Sørensen and Levinsen 2014a, and 2014b) and emerging learning designs (Levinsen and Sørensen 2015). We argue that this is due to the project's emphasis on the value of practises that are not new for children, but rather are embedded in their informal play practises (Sørensen, Audon and Levinsen 2010; Wahlgren and Aarkrog 2012). As demonstrated in the examples from the second grade, we have found that designs for learning that encourage children's playful learning practises and creativity support the students in becoming *self-programmable* and break them of their *downloading* habits*,* while at the same time facilitating the transformation from experience to digital literacy. Boden (1990) identifies three ways of exercising creativity:

- *Combinatorial creativity*—unfamiliar combinations of the familiar inspire associations that allow new ideas to materialise;
- *Explorative creativity*—when a 'space', defined by domain-specific generative rules, is explored for potentials and limitations, and the space is subsequently expanded;
- *Transformative creativity*—when a 'space', defined by domain-specific generative rules, is not only expanded, but the defining rules are changed into new and fundamentally different rules and ideas.

According to Boden, it is not possible to plan for specific creative products or processes. It *is* possible, however, to design obstructions that challenge students in various ways towards creative agency, and that in this context are aimed at digital literacy. Combinatorial creativity may be challenged if the teacher designs obstructions in terms of deficiencies that invite students to think of and use familiar technologies in unfamiliar ways, thus consolidating or expanding their *digital competence*. Correspondingly, explorative creativity may be challenged by technological obstructions that result in dilemmas between 'giving up' or finding alternative ways within (or expanding) the *corpus of digital usages*. Dilemmas may be solved, while paradoxes cannot. Accordingly, technological obstructions that generate paradoxes challenge transformative creativity, as the choice lies between 'giving up' or doing/thinking the impossible—that is, to radically break with *downloading* and to change the basic assumptions and premises in relation to the role and agency of digital technology.

5. Approaches to acquiring digital literacy

The teacher can choose various organisational forms (e.g. peer, group, expert, chain or moving freely in the classroom) to encourage immediate or formalised knowledge-sharing between students by implementing the class-principles '*Ask a child before a grown-up'* and '*Help others to do it themselves',* and by appointing class-experts. The teacher can reorganise the class time by shortening instructions and allocate time to teacher-facilitated student activities. As learning designer, the teacher prepares space and time for individual-level as well as collaborative tinkering, experimentation, accumulation of experience and reflection on technology, such as in the example of the creation of the ad-hoc iMovie group.

Digital competencies are basic requirements for performing specific actions using digital resources. Students experience the intricacies of digital architecture and infrastructure when they install or delete software; distinguish between file types; struggle with the difference between a hard disc, a memory stick, a shared network and the cloud; or navigate between applications, apps or windows. When they explore features and affordances and apply these in digital productions, they build a set of knowledge of typical ways of interaction that forms the basis for transfer and the figuring out of as-yet unknown applications. In order to acquire, maintain and develop the digital competencies, students need regular, consistent space and time to experience, articulate and reflect upon obstructions that occur with any digital resource that is in use in the school. The learning design can set an arena for basic technological obstacles and can prompt *combinatorial* and *explorative creativity* by requiring that the students work on local devices and share final productions on networks or in the cloud. Peer evaluations are also liable to produce obstacles, as they presuppose that the students are able to retrieve the work of their peers. Here the class-experts are part of the learning design as they relieve the teacher of the most common challenge—the time-consuming and frustrating '*The teacher deals with all kinds of technical issues'* problem*.* On the other hand, it is the teacher's responsibility to transform unexpected situations into learning experiences for the students: the obstacle *'Running out of space on the device'* can be turned into the explorative student task of '*Find out how and what to delete and where to save material that needs to be stored'*. The obstacle '*The mathematics problems are too easy/difficult'* can be turned into the explorative student task: '*Find out how to change the difficulty settings in the mathematics app*', both followed by the class-principle *'Prepare to tell/help others'.*

A corpus of digital usages is a combination of digital competences and various strategies for agency that allow an individual or a group to change practise. In the above example with Parsley and Olivia and their horror movie–trailer, the students explored iMovie for features and affordances outside of school. They found that the teacher ought to know about the genre templates and wanted to suggest them for school purposes. The students exercised *self-programming,* as well as *combinatorial* and *explorative* creativity, when they produced their trailer. The teacher, on the other hand, caught onto the students' initiative and extemporaneously turned their trailer-experiment into a subject-related activity where the class exercised multi-modal analysis and formulated criteria for evaluating the progression of the subsequent digital genre–production towards the learning objectives. This example shows how the teacher was able to turn an unexpected incident into a learning experience. The learning design can create an arena for digital usage obstacles, and can prompt *combinatorial* and *explorative creativity*. The design can do this by 1) introducing new applications that have to be explored for their potentials, 2) omitting certain digital resources in relation to a specific subject-related production or 3) both. In such designs, some of the students may become class-experts.

Digital transformation is the capability of 'thinking outside of the box' and creating something new within the digitalised environment. This is a core twenty-first-century competency that is not exclusive to digital transformation. It essentially means to be *self-programmable* and capable of breaking with *downloading*. Digital transformation is therefore one approach to exercising the general future-oriented transformative competence of 'learning-to-learn'. We have only rarely observed digital transformation 'just happening', but when Parsley and Olivia managed to change the basic rules of how technology enters the classroom and inspired the teacher to change her approach to the upcoming subject, we argue that in this sense they acted in a *transformative* manner. The learning design can create an arena for digital transformation obstacles, and can prompt *transformative creativity* by demanding that students explore entirely unknown digital resources, report their perceived usages by actually testing and evaluating them. In this way, students gain experience that technologies are not stable entities and build their competencies to learn-to-learn.

6. Progression or regression of digital literacy

The approaches require teacher surveying of the students' progression/regression. When students become accustomed to particular practises, their knowledge and competencies are transformed into *tacit knowledge* (Wackerhausen 1990a, 1999b) that is no longer an object of conscious reflection. As a result, it is difficult to modify tacit practises that have become inadequate, or indeed a barrier to new learning. If this happens, the development of students' competencies for learning-to-learn and their digital literacy is at risk of coming to a stand-still: that is, progression turns into regression. For the teacher, it is therefore important to facilitate students in navigating the borderland between tacit *downloading* strategies and breaking with *downloading*. It may be difficult, however, for the teacher to distinguish between routinised tacit knowledge and outright learning challenges. In order to identify students' positioning in this borderland over time, we suggest paying heed to the following indicators (Levinsen and Sørensen 2011):

- When students display difficulty in changing between agency and reflection in their learning processes, and typically act within an unreflective *trial-and-error* pattern, we consider them as challenged learners.
- When students prefer to act immediately and avoid the externalisation of ideas and planning—and typically act within a reflective *learning-by-doing* pattern, and rely on *downloading* when breaking with *downloading* would make more sense—we consider them as acting routinised learners.
- When students shift effortlessly between agency and reflection and between the future-oriented planning perspective and the here-and-now practise-perspective, and typically act within '*reflection on action'* and '*learning-by-doing'* patterns that break with *downloading* when necessary, we consider such students to be *self-programmable*.

6. Discussion

Our analysis shows that various ways of integrating ICT, digital media and subject learning support students' acquisition of digital literacy, and that the relation between ICT in learning and digital literacy is neither straightforward nor deterministic. The positive effects will be found when students act as learning designers, as previously described, and in settings where they are challenged by unknown technologies, or by using known technologies in unfamiliar ways.

The examples are drawn from the second grade, but we found differences between the second graders and the older students we followed. While the younger students approached digital devices with the same ease with which they used other artefacts, the older students were more reluctant and often waited for the teacher's instructions before using their digital devices. In addition, the younger students were quick to explore new apps and to suggest potential uses for apps. They helped each other spontaneously, and were good at explaining features while still leaving their peers in control. We especially saw that when they produced learning designs for programming and assignments in relation to *LEGO WeDo®*, they produced multimodal instructional designs in different genres aimed at other students by using the ebook creation app BookCreator. For the older students working with *LEGO Mindstorm®*, this appeared to be much more challenging, and only a few managed to expand their digital instruction beyond text. In projects where second and sixth graders worked together, the younger students were confident in the use of ICT. The only situations in which the sixth graders were superior were in relation to interactions with complex digital architecture, such as setting up a blog and setting up the rights of the invited users.

We explain these differences as stemming from the differences in the students' experiences. While the younger students only experienced school in the role of learning designers who were engaged in digital productions, the older students thought of themselves as being in a traditional school where ICT was occasionally present, and where digital productions were defined by teachers. As the different approaches emerged and were implemented during the project, the younger students gradually expanded and consolidated their informal competencies, while their older peers had to recapture lost ground by understanding that their informal competencies were both acceptable and useful in the school context. While following the older students over the course of 1½ years, however, changes emerged that confirmed that when the teachers exercised awareness and facilitated digital literacy, the sixth graders gained digital literacy. For example, they began to explore new technologies and to spontaneously share users' ideas, and they transferred interactions and practises between contexts. They demonstrated an interest in the reliability of their search findings and, without their teachers' interference, a few students used Skype to communicate with their peers, for example when they were physically scattered in the school or when a peer was sick at home. They also began to use production tools such as Google Docs and BookCreator to collaborate, plan and document their work, and not only for the purposes of creating final productions and presentations.

In our study, there is evidence that our suggested learning designs and approaches hold promise for an ongoing consolidation and development of students' digital literacy. We thus suggest as future research that these approaches should be thoroughly challenged in practice.

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