Routledge
Taylor & Francis Group

Oxford Review of Education

ISSN: 0305-4985 (Print) 1465-3915 (Online) Journal homepage: http://www.tandfonline.com/loi/core20

Technological literacy for teachers

Cathrine Hasse

To cite this article: Cathrine Hasse (2017) Technological literacy for teachers, Oxford Review of Education, 43:3, 365-378, DOI: 10.1080/03054985.2017.1305057

To link to this article: http://dx.doi.org/10.1080/03054985.2017.1305057

OXFORD REVIEW OF EDUCATION, 2017
VOL. 43, NO. 3, 365–378
https://doi.org/10.1080/03054985.2017.1305057

Routledge
Taylor & Francis Group

Technological literacy for teachers

Cathrine Hasse

University of Aarhus, Denmark

ABSTRACT

Ongoing developments in educational technologies place increasing demands on teachers who have to make decisions on a daily basis concerning how, when, and where to make use of technologies in classrooms. Building on results from the Danish project Technucation, this paper argues that there is a marked need for a teacher-specific version of the technological literacy developed by the International Technology Education Association (ITEA). ITEA defines technological literacy as the ability to 'use, manage, assess, and understand technology'. The Technucation project found that teachers were not simply in need of knowledge about how to manage technical challenges, they would also benefit from awareness of how new technologies change relations, identities, and complex power structures. The paper explicitly addresses this issue of the new skills and analytic capabilities that teachers need in order to engage effectively with technological development. The type of enhanced technological literacy teachers may benefit from is represented in the paper through its presentation of the *TECS*-model, developed in the course of the Technucation project: hands-on skills in handling *Technology* (*T*); capability to analyse changes in *Engaged relationships* (*E*); capability to analyse *Complex power-informed pathways* (*C*); and capability to analyse long-term *Shifts in professional identities* (*S*). The paper argues that attention to all of these areas should be included in the education of technological literacy to pre-service teachers.

KEYWORDS

Educational technologies; technological literacy; human–technology interactions; digital natives; educational inequality

Introduction

In the late capitalism of the Western world (Jameson, 1991), the educational system is exposed to massive pressure to buy and use new educational technologies, defined as 'physical media designed to support teaching situations and learning processes' (Luppicini, 2005, p. 106). The 'distinctive ethical concerns' of these technologies 'focus on the processes of creating instructional materials and learning environments and on relations with learners during the use of those materials and environments' (Molenda & Robinson, 2008, p. 245). Education is today strongly connected to the skills that, for instance, the OECD (Organisation for Economic Co-operation and Development) considers to be in demand by the labour market, in what they term a focus on 'intangible assets' such as 'knowledge-based capital' (OECD, 2016, p. 33). The OECD advocates that '[t]hrough ICT-related education, training and

CONTACT Cathrine Hasse caha@dpu.dk

re-skilling, people must be equipped with the appropriate skills to make use of ICTs and to manage risks to their online social and economic activities, with a view to fostering entrepreneurship, employment and e-inclusion' (OECD, 2015, p. 12).

Although educational technologies of various kinds—quill pens, books, exercise books, blackboards, and chalk—have existed as long as we have had schools and students, electronic educational technologies should, in techno-future oriented Western societies, be seen as part of a new political agenda. Today, a plethora of new software and hardware have proliferated from technology companies (such as Apple, Lego, Microsoft etc.) who have a commercial interest in driving education. These electronic educational technologies encompass 'both the hardware that enables access to digital resources and networks, and the uses of those resources and networks' (Davies & Eynon, 2013, pp. 1–2), and can therefore be considered as more than material objects. Rocci Luppicini sees educational technologies as a

> goal-oriented problem-solving systems approach utilizing tools, techniques, theories, and methods from multiple knowledge domains, to: (1) design, develop, and evaluate human and mechanical resources efficiently and effectively in order to facilitate and leverage all aspects of learning, and (2) guide change agency and transformation of educational systems and practices in order to contribute to influencing change in society. (Luppicini, 2005, p. 107)

In practice, educational technologies are also mercantile, commercial agents of change in education working in unexpected ways. Schools have for a long time found it challenging to fulfil promises of a seamless connection between material artefacts and their systemic workings in education in practice. Some of the responsibility for the difficulties experienced in this respect can arguably be located on the teachers' side of the human–technology interaction: although new electronic educational technologies are often defined as the solution to learning problems in schools, many teachers lack the skills and understandings necessary for incorporating these new technologies into their practice. Managers increasingly perceive this solely as a question of developing teachers' technical skills, but given the fact that the demands of new technologies do indeed reach beyond the material, we argue that there is an equally urgent need for a more comprehensive technological literacy. Some have argued that the problems would be solved as older teachers are replaced by newer generations of 'digital natives' (Prensky, 2001), but there is as yet little evidence to suggest that time alone will resolve these difficulties (e.g. Helsper & Eynon, 2010). Therefore, it is more important than ever that teachers learn to deal with how educational technologies affect teaching and learning in school, and to understand that this involves rather more than technical skills.

The Technucation project

The Danish project Technucation explored how to improve the teaching of technological literacy in Danish teacher education over a four year period (2011–2015).[1] The main idea was that pre-service teachers needed to learn about the general technological literacy which in-service teachers called for in their everyday practices. Therefore the project first explored the technological literacy needed by teachers in everyday school practices and next developed the insights from this research into a teaching tool for pre-service teachers (the TECS-model). The Technucation project was coordinated by myself, and the researchers were a mixed group of professional workers, two PhD students, assistant professors, associate professors, research assistants, and student assistants from the institutions Aarhus University,

the two professional colleges UCC (University College Copenhagen), and Metropol, and further entailed a collaboration with the Danish Technological Institute and Roskilde University. The researchers visited 32 institutions in the period from March 2011 to June 2013 and made participant observations in 10 selected institutions and in-depth interviews with 150 informants (73 working with technologies in school settings and 77 in hospitals).[2]

A survey among pre-service teachers as well as pre-service nurses conducted for Technucation by the Danish Technological Institute in 2011 showed that it cannot be taken for granted that new generations of teachers (Kristensen & Johannsen, 2012), simply by virtue of their upbringing with computers, master the digital world sufficiently well to exploit its benefits and capacity in educational settings. In the Danish survey, launched by the Technucation project, most students (the pre-service teachers) expressed a positive view on technologies in education. Nevertheless, only 29% of the students in the survey from one of the largest Danish institutions of teacher education (UCC) confirmed that they, to a high or very high degree, have learned to deal with the changes stemming from new technologies in their professional work as teachers. Regardless of age, more than 40% estimate that they do not have the necessary technological qualifications for using new technologies in their teaching (Kristensen & Johannsen, 2012, pp. 24–25). This is in line with other research that refutes general notions of all young people as 'digital natives' (Bennett, Maton, & Kervin, 2008; Geck, 2006; Helsper & Eynon, 2010). Based on the Danish survey, the Technucation project set forth to investigate, among in-service teachers, the skills that pre-service teachers need as a supplement to existing teacher preparation in order to become technologically literate regardless of age.

We found that in school practice the ability to handle and understand technology is not an isolated skill tied to the individual teacher. By visiting schools and engaging in ethnographic studies of how technologies were used in everyday situations, the findings from the Technucation project addressed questions of how new technologies affect relations between students and teachers and managers in schools in complex ways.

Methods

The central objective of the project research was to generate knowledge about the gap between the impacts of technologies, the needed (often technical) technological literacy as envisioned by their designers and decision-makers, and the actual problems and potentials encountered when teachers use technologies in everyday practice. Technucation's basic research questions regarding technological literacy for pre-service teachers were:

- What do studies of everyday use of technology in situated professional in-service teachers' practices indicate about the technological literacy needed?
- What kind of technological literacy do pre-service teachers need to learn?

The project had a 'mixed method' design, in the sense that the quantitative methods were not just embedded in the ethnographic approach (Creswell, 2009, p. 280); rather the qualitative and quantitative methods were based on each other's results and they evoke different phenomena.

Technucation adopted a phased approach, alternating between quantitative and qualitative studies as a way to guide the development of a new understanding about actual teachers' technological literacy and, on the other hand, what emerged as actual data about the need for an improved technological literacy curriculum for pre-service teachers. In 2011,

the survey conducted among pre-service teachers at a teacher college was forming a backdrop to the subsequent development of research guidelines and questionnaires (Kristensen & Johannsen, 2012). In 2012, we conducted a pilot study, which involved three researchers carrying out ethnographic fieldwork in three schools. They conducted ethnographic field observations and interviews with 15 primary and secondary school teachers following an observation and interview guide inquiring into experiences with educational technologies. Empirical ethnographic studies revealed that the influx of educational technologies changes classroom practices in many ways, and raises the question of how we are to understand 'technology as a cultural force transforming the identities of teachers and pupils as well as the ongoing learning in the cultural ecologies of schools' (Hasse, 2016, p. 2).

Though fieldwork in classrooms has many downsides (being based on 'cases', building on descriptive subjective observations of ethnographers etc. [see Hammersley, 2006]), the method has the advantage of moving the researchers to 'go beyond' what is supposed to take place and enable the formulation of new questions tied to what is actually taking place (Hasse, 2015). This pilot study made us note, among other aspects, that when talking about educational technologies, the teachers almost always referred to 'new electronic' technologies rather than books and blackboards. Furthermore, even this small study made us aware that many other factors were important for good teaching with educational technologies like tablets, interactive whiteboards, and 3-D printers than an understanding of how to use technology technically.

In our original coding via the software analysis programme, Atlas.ti, during the pilot stage we identified 34 codes revealing the complexity of how, when, and by whom educational technologies were used and reflected upon in schools. This coding indicated, for instance, how educational technologies such as new communication systems transformed concepts of time, learning, gender, and proximity relations between students, students and teachers, teachers and managers, and teachers and parents. In many of the classes we visited, some students were better than the teachers at operating the new educational technologies (such as software programmes). In some classes the teachers saw this as a resource, while in others it created tensions. In some instances it also created gender tensions as most of the technologically skilled students were boys. Some teachers felt that their experience and skills as teachers were superseded by the new software. Others expressed that the US software challenged what they saw as classic Danish values, which have an emphasis on equality and cooperation whereas the software encouraged competition in the classroom.

In relation to human–technology interactions, we found a huge variation in the type of technologies that were chosen mainly by municipal staff and school managers, as well as a great variety in the reasons that these technologies were preferred. We found less variation in how teachers experienced the time and resources allocated to learn to operate new technologies—in general the teachers complained of a lack of time to familiarise themselves with the technologies chosen by their management. It came as a surprise for many that new technologies had so many unexpected effects on teaching and learning practices and how they, over time, challenged existing learning paradigms.

In a follow-up to the pilot study, four researchers enhanced the findings by making more observations in classrooms (including two new schools) where 60 new interviews were conducted, primarily with primary and secondary school staff but also managers, IT consultants, and teachers from the teachers' education college (in both the pilot and follow-up study a total of 73 interviews were conducted).

In the next phase of the Technucation project, we reduced the coded complexities to four main areas which the research group found was fundamental for teachers' technological literacy: technology in itself, engagements in use, complexity in decision making, and long-term shifts in the profession of teaching. The coding of the material was then reduced to these four categories.

Findings were explored through a method of culture contrast, in which we explored what we identified as teachers' interaction with technologies; success stories and failures in one setting were contrasted with other settings. Likewise, findings from the qualitative studies were contrasted with the quantitative data. This method originated as a contrast between interview statements (Hasse & Trentemøller, 2009), but was here extended to all kinds of data material. This approach allowed us to discover tendencies across the data material and discover diversity in, for instance, one or more school settings and municipalities, but not in others.

In 2013–2014—in collaboration with local teachers from some of the schools we had visited as well as educators from UCC (Hasse & Brok, 2015)—the research group developed the results of the qualitative research into prototypes of a new learning tool for a practice-based technological literacy guide, which eventually got the name the TECS-model (see Figure 1), to be tested and used by pre-service teachers at UCC:

T = *Technology* as design and learning intensive device;

E = *Engagement* in using technology in situated practice;

C = *Complexity* and often diverse networks comprising technology;

S = *Shift* in professions through the use of technologies.

In relation to the data material on teachers, the model showed four main areas where the data material pointed to how educational technology influenced and changed teaching and transformed learning and how the process of teaching could be helped with technological literacy in these four areas.

Based on findings and analysis we developed the Danish textbook *The TECS-model* (Hasse & Brok, 2015), which is a learning tool for how pre-service teachers could prepare themselves for the effects of new technologies in practice. It is a model for a new technological literacy suitable for teaching about educational technology, and it covers technological literacy in relation to technology-design, engaged practice, complex choices, and long-term shifts in professional identities. The four areas presented in the TECS-model give a systematic overview of the complex technological literacies needed to teach pre-service teachers about the type of general technological literacy that is demanded in the job of teaching.

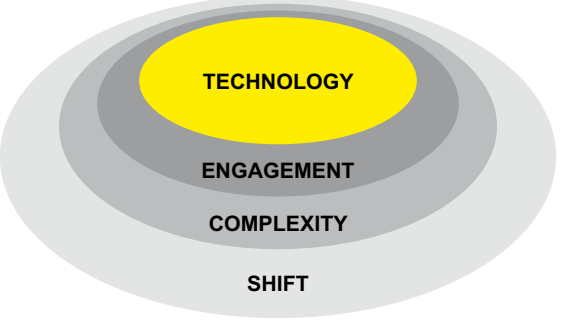

Figure 1. Technology, Engagement, Complexity, Shift, in short the TECS-model (Hasse & Brok, 2015, p. 19).

Finally the new learning tool, summarised in the TECS-model, was tested by the Danish Technological Institute with the aim of discovering the effects of its use when used in pre-service teaching at a teachers college. Together, Technucation and the Danish Technological Institute organised a test at UCC teachers' college, where an intervention group was introduced to the TECS-model, while the control group was not (i.e. a so-called randomised controlled trial, RCT-inspired research design). Both groups were then asked to fill in a questionnaire with 37 questions to test the effect of the TECS-model. Of these questions, eight were identified as core questions; 197 pre-service teachers completed the questionnaire. Though it proved difficult to teach a new technological literacy in the six hours of teaching allotted to the groups who were taught the new TECS-model, some significant changes could be detected. Out of 37 questions, significant differences were found in seven questions of which five were core questions (with a significance level of ≤0.05). The pre-service teachers that were taught technological literacy from the TECS-model were, for instance, much more aware than the control group that technologies were not just tools (Fragtrup & Burlin, 2015, pp. 10–11).

In the following part I shall illustrate how the technological literacy required by teachers often went beyond the 'pushing button' skills.

Enhanced technological literary

> The time is 8:00 am and school starts for 22 pupils and one female teacher in 1st grade b. There are many electronic educational technologies in the room: a SMART board, mobiles, a whiteboard, a projector, a microwave oven, a refrigerator, boxes with headphones, boxes with wires and equipment for charging computers. All pupils have their own electronic notebook, which they take out of their bags. The table layout is set as a horseshoe. The young pupils (age 6–7) swarm in, sit down on the chairs, and immediately open their computer so they light up. Pupils start with individual reading for the first 20 minutes. They read in books or on notebooks and on a website about 'Danish animals'. The children begin at 8:10am but there is something wrong with the updates on one of the pupil's electronic notebook and therefore three other pupils help him. The teacher later explains that the three pupils in the class are appointed as experts in helping and today a fourth pupil is also appointed. They are all boys! The children discuss updates, locks, USB connections and photo shop with each other. They already master a language for technology use. (Excerpts from Technucation fieldwork notes—L. B. Field Notes, Brok 2014)

One of the main findings of Technucation is that teachers lack the technological literacy necessary for handling how new educational technologies may have the unforeseen consequence of creating new inequalities in a classroom. When technology engages with practice, 'button pushing' literacy must be enhanced with an awareness of how educational technologies affect social relations. In many instances, where new technology was implemented, the teachers sought help from a particular group of 'tech-savvy' (Hicks, 2011) boys, as in the above examples. This group of boys could have been the digital natives envisioned by Prensky (2001), but they were far from representative of the classroom as a whole. As a result of the teachers' lack of technological literacy, we noticed a shift from a professional (subject matter) commitment towards a technological commitment—and the pupils (boys and girls) who were particularly engaged in the subject matter were set apart from students with technical skills. In many situations, making the technology work was prioritised over the content. In the TECS-model we discuss how an enhanced technological literacy must include an awareness of how 'engagement' changes when technologies are used in situated practices.

In more than 80% of the interviews (73 in all), informants mentioned new electronic hardware and software devices as especially salient educational technologies. Many referred to these new technologies as time-consuming and explained they had to learn many new things when they began to use the technologies in their actual teaching practice. For most of them, the learning took place at home rather than in professional contexts:

> It is fun. I learn it at home, I like gadgets, and when I play with something, then I think of my fourth grade—how can we use this stuff? (Nete, teacher)

Some teachers, however, gave up learning the 'pushing button' skills after they had tried to engage with new technologies for a while. We saw a good deal of 'dusty technology' which had been abandoned because the teachers gave up figuring out how to make sense of it, when we visited schools.

The technical challenges are real. Most municipalities had not thought about investing in server power when they began their heavy investment in educational technologies, regardless of whether there were stationary computers or tablets for all pupils in the municipality, or interactive whiteboards. Furthermore, it was up to the teachers to discover the different effects the new technologies had in practice. All the teachers we spoke to found many exciting opportunities with the new technologies and all experienced the same kinds of frustrations because the technologies did not work as planned in practice. However, the real reason for not using a new technology is not always remedied by technical solutions and 'pushing button' skills. It concerns ownership.

The teachers expressed a need for a better understanding of why and how new technologies find their way into the classrooms. In most cases, they had not chosen the hardware platforms they worked with (be they PCs, tablets or interactive whiteboards), and in many instances managers and even municipalities determined the access to software systems, which was often affected by commercial interests. When these solutions were implemented in the classrooms, they generated new tasks and decision-making demands for the teachers, with the teachers having to deal with, for instance, all the 'disturbances' stemming from new technologies.

Regardless of gender and age, teachers often felt left behind because they received very few guidelines on how and why new technologies should be coupled with professional subject matter insights. They were often in doubt as to why particular programmes are chosen over others—and many lament that they have no influence on the assessment procedures.

> We cannot choose what programs to include as relevant for our subject matter. This is all decided by our municipality. They buy everything for us and install it at all computers (…) It is the ICT-guys in the municipality who decide it all (…) It does affect our work with subject matter. Every time we import a new thing, something else has to go. It seems like 'appearance' and acceleration comes before in-debt learning of subject matter. (Carsten teacher)

Specific educational technologies were decided by individual municipalities, or school management, and despite a wide range of different types of tablets on the market, all the schools that invested in tablets for their pupils chose the same brand: iPad. Those who invested in interactive whiteboards all bought SMART boards. When deciding upon a product, the municipalities conferred with consultants from commercial companies such as Apple, Microsoft, and SMART boards together with locally appointed representatives (typically teachers known to be especially ICT knowledgeable) or locally appointed ICT consultants (who could be special ICT super-user teachers) from the schools. The overwhelming presence

of particular brands showed itself in our interviews, where no informant referred to, for instance, 'tablets', but only iPads. We found only few instances where schools invited 'subject matter' teachers without a particular knowledge of ICT into these ICT counselling boards.

A few managers acknowledged the human aspect of the human–technology relationship and offered further possibilities for knowledge sharing and time for learning in depth about the possibilities of the technologies. Most of the managers we spoke to saw the technologies they selected as 'intuitive'—and did not give teachers time for subject matter discussions on how to use them. The complex paths through which educational technologies found their way to classrooms involved an awareness of how 'pushing button' skills, ownership, and managerial and commercial interests are entangled and a technological literacy is needed to deal with this complexity.

The above examples reveal a need for an enhanced technological literacy enabling teachers to understand the *Technology* (*T*) in order to analyse and act on issues such as the relation between servers, networks, and the local workings of hardware such as tablets; they need a capability to analyse and act on changes in *Engaged relationships* (*E*), e.g. between boys and girls when new technology is introduced into classrooms; they need the capability to analyse and act on the *Complex power-informed pathways* (*C*) that deprive them of ownership of educational tools; and finally they need the capability to analyse and act on the long-term *Shifts in professional identities* (*S*) following a plethora of new educational technologies.

The model functions as a visual reminder for how to be an exemplary technologically literate teacher. It comprises all the analytical findings in Technucation, reduced and refined into what we call a 'teaching tool' of an enhanced technological literacy for pre-service teachers. It may be misleading to talk about an 'enhanced' technological literacy as the literacy we found lacking in pre-service teachers differs considerably from the already existing curriculum of technological literacy in use in the STEM-related areas. Even so, we argue that this new way of thinking about technological literacy is an important step towards increased awareness of the human–human aspect in all human–technology interactions.

Discussion: technological literacy revisited

Technological literacy has, for a long time, been part of the school curriculum in the so-called STEM subjects (Science, Technology, Engineering, and Mathematics), not least in the United States where prominent physicists, engineers, and mathematicians have joined forces to formulate principles and standards for understanding technology (ITEA, 2000/2007). In this context, technological literacy refers to the skills needed to understand and handle the workings of technologies that are at the core of many 21st-century demands. Therefore, it is considered necessary to educate the future generations who are envisioned to become our future technology developers (e.g. engineers, physicists, and mathematicians), as well as the general public.

Since the 1980s, technological literacy has emphasised technological skills in the education sector, e.g. the so-called New Liberal Arts (NLA) programme in 1982. This programme, funded by the Alfred P. Sloan Foundation, had as its main objective to improve general undergraduate programmes with knowledge of the technical sciences in the United States. In the wake of this acknowledgement of a need for STEM-related technological literacy came a wealth of publications on technological literacy, mainly formulated by engineers and natural scientists (e.g. Gamire & Pearson, 2006; Pearson & Young, 2002) who were affiliated with

the National Academy of Engineering (NAE). These publications typically offered a large complex of definitions, standards, research, and policy-oriented literature suggesting a pre-defined curriculum for skills resulting in Standards for Technological Literacy (STL) (Dugger, 2001; ITEA, 2000/2007).

Originally, this new focus challenged the widely spread understanding of technology in the STEM-area as an 'applied science' (with the traditional separation of an 'engineer understanding' and a 'science understanding' of technology [Petroski, 2010]). Since the 1990s, technological literacy has also been considered of importance for areas within the social sciences and the humanities, for example electronic communications, quantitative sociology, architecture, etc. This movement initiated an effort to incorporate technological literacy into all educational programmes and not just the established STEM subjects, where technological literacy most naturally belongs (Bassett et al., 2014). 'Technological literacy' began to be a generally accepted term used to describe a broad understanding of technology as an aspect of being an educated citizen (Ames, 1994). Broadly speaking, technological literacy became the ability to learn to read technology as it was presented in the book *Tech Tally*:

> First, a technologically literate person must have a certain amount of basic knowledge about technology. Second, a technologically literate person should have some basic technical capabilities, such as being able to work with a computer and to identify and fix simple problems in the technological devices used at home and in the office. More generally, he or she should be able to employ an approach to solving problems that relies on aspects of a design process. And third, a technologically literate person should be able to think critically about technological issues and act accordingly. (Gamire & Pearson, 2006, pp. 1–21)

This broad definition moved technological literacy from the concern of the STEM area to the area of the general consumers of technology, i.e. as existing human-made processes and products viewed from the consumer's perspective (Krupczak & Blake, 2014). Yet, along the way some critical voices also began to appear (Dakers, 2014a, 2014b). It became clear that technology was not just made for the benefit of the consumers (including school-based consumers). The development of new technologies was also the development of sale products often developed by a group of people with very little insight into the effects of their productions. The philosopher Albert Borgmann defines technology as two-sided: on the one hand, it is hardware, for example chips, cables, and screens, associated with software such as lines of codes developed by engineers; on the other hand, technology is a cultural force that affects people's lives (Borgmann, 2006, pp. 352–353).

However, in a review of the concept 'technological literacy', the Technucation project found that most of the discussions on technological literacy were not based on empirical research of how, for instance, teachers experience and deal with technology in their everyday practices (Wallace, 2011; Hasse & Wallace, 2012). Technological literacy was mainly debated in relation to the development of curricula and the education of technologically literate citizens (Yawson, 2010, p. 7). Furthermore, most literature on technological literacy takes a generalised human being as 'the human' in human–technology interaction and thus tends to overlook the technologically diverse effects on humans in the plural.

In this respect, the TECS-model contributes to the core of existing literature on technological literacy by drawing attention to four aspects: (1) it involves local human–technology engagements; (2) it may involve changes in human–human relations; (3) which may be affected by complex power structures and (lack of) ownership; and finally (4) long-term shifts in how subject matter and professional identities are affected by educational technologies.

Conclusion

The TECS-model is based on Technucation's empirical research of teachers' practices with technologies, and we identified ways of making a model of technological literacy that covers how technology changes human–human interaction, inequalities, and power relations not included in the one presented by Gamire and Pearson. As part of their training, pre-service teachers need to acquire (as mentioned by Gamire and Pearson) 'basic knowledge about technology', 'basic technical capabilities', and some degree of basic knowledge about design processes. These aspects are comprised under the T in the TECS-model. However, in order to 'think critically about technological issues and act accordingly' (Gamire & Pearson, 2006, p. 21), we also suggest that pre-service teachers address the underlying assumptions of the type of technological literacy offered by engineers and ICT-educators from the STEM area. This might be addressed with the enhanced TECS-model that includes insight into how technologies affect and are affected by the human aspect in human–technology interactions.

New and commercial technologies are constantly introduced into the school area, which demands training of the people expected to use them. This makes it difficult to follow suit, even for research into the effects of educational technologies (Roblyer, 2005, p. 193). Many studies demonstrate on a general level 'how digital technologies can be used effectively to facilitate teaching and learning in the 21st century. However, the insights gained from these studies often do not result in the uptake of technologies in educational practice' (Voogt & Knezek, 2016, p. 1).

In our Danish study, computers and other technical equipment were 'underused'—not necessarily because of teachers' reluctance, but tied to an overload of constantly shifting technological equipment that, in subtle ways, turned out to be 'oversold' (e.g. Cuban, 2001): new technologies are not nearly as intuitive as claimed. Managers systematically overlook the learning demands following from implementation of, sometimes 'immature', technologies and the importance of ownership. Most reports on implementing 1:1 devices, such as iPads, have many positive findings; among others, increased student motivation (see e.g. Karsenti & Fievez, 2013). The positive motivational effect of using electronic educational devices is not in dispute here, but the ethnographic studies revealed the extent of the complexity that teachers have to deal with on an everyday basis in their struggle to handle unexpected effects of bringing these devices to work in practice in school.

One of the main conclusions of the Technucation project is that pre-service teachers need to acquire enough enhanced technological literacy during their training to be able to deal with the ways technology influences teaching and learning in practice in the classrooms. The Technucation research raises new questions such as:

- How can teachers ensure that break downs or gaming do not disturb education?
- If a particular group of male students are recognised as digital natives, how are the rest of the children viewed?
- How can teachers gain ownership over the technologies used?
- How can teachers keep up with the continuous flow of educational technologies?

New educational technologies emphasise new skills, and they create new divisions among the groups of students as well as teachers. Teachers with technological literacy should not regard educational technologies as innocent tools that automatically enhance subject matter learning—rather they should analyse how new human–technology relations affect different

students' de facto learning with educational technologies. Technucation challenges the seemingly widespread notion that technological literacy is primarily connected to the STEM-related areas.

Based on the ethnographic analysis of the Technucation data, we can conclude that educational technology *does* change what goes on in the classrooms—albeit in ways that often differ markedly from the expectations of the managerial buyers of 'oversold' tablets and other technologies. The findings of the Technucation analyses also reveal complex diversity in the uptake of new technologies, with teachers not necessarily always learning to deal with this complex diversity. This is recognition of how educational technology is not just a means, but also an education in itself (Petrina, 2003). Since many in-service teachers do not get help assessing and using technology, and since they have to manage the effects of new technologies largely on their own, much time and energy is wasted when the teachers struggle to find their way around unexpected consequences of new technologies (Wallace & Hasse, 2014).

Teacher education rarely equips pre-service teachers with the necessary insight into how technological literacy is not just about 'button pushing' skills and not just tied to STEM-related topics, but also includes the ability to deal with new diversities in the classroom and new demands for technology assessment in relation to subject matter content.

The time has come to acknowledge the enhanced technological literacy pre-service teachers need in order to overcome the enormous difference in learning opportunities, which have been identified in empirical studies of practices with new educational technology inside the classroom. New educational technologies create new kinds of inequalities, for instance, between students who get distracted by the new gaming possibilities and students who engage in subject matter without 'button pushing' skills. The range of available technologies for young people (Davies & Eynon, 2013) in Western countries constitutes a learning environment that creates competences in manoeuvring the digital universe. However, being a digital native is, according to Technucation, not simply a matter of being able to handle technology, but also being able to consider and reflect upon the wider effects of technology use (Hasse & Brok, 2015). Teachers need to develop an enhanced technological literacy in order to meet these challenges. It matters how future pre-service teachers learn to handle educational technologies, both as a means of teaching subject matter, and a means of shaping education and learning in a 21st-century society.

Notes

1. Nurses' pre-service education was also included in this project, but it is left out of the argumentation here as the focus is on teachers' need for technological literacy. It was, however, also concluded in Technucation that nurses also need an enhanced technological literacy in order to perform skilfully, and that future pre-service nurses are not necessarily digital natives.
2. Only 149 interviews were conducted, but in one interview two informants were interviewed together.

Acknowledgements

To all the participants, researchers and informants, as well as the Strategic Research Council in Denmark, thank you for making the Technucation project possible.

Disclosure statement

No potential conflict of interest was reported by the author.

Funding

This work was supported by the Danish Research Council [grant number 0603-00382B].

Notes on contributor

Cathrine Hasse is full Professor at Aarhus University in Denmark in the Department of Education. She leads the research group Future Technologies, Culture and Learning, engaging in research on educational technologies and global cultural learning processes. For four years (2011–2015) Cathrine was the coordinator of the research project Technucation on learning and technology and from 2016 to 2020 she is heading the EU project on robotics, REELER. In her work she takes a special interest in the relations between technology, culture, and learning. She is the author of *An anthropology of learning: On nested frictions in cultural ecologies*, published by Springer in 2015.

ORCID

Cathrine Hasse http://orcid.org/0000-0002-2525-9540

References

Ames, O. (1994). A program for technological literacy in the liberal arts. *Journal of College Science Teaching*, March/April, 286–288.

Bassett, G., Blake, J., Carberry, A., Gravander, J., Grimson, W., Krupczak, J. Jr., Mina, M., & Riley, D. (Eds.) (2014). *Philosophical perspectives on engineering and technology literacy, I. electrical and computer engineering books*. Book 1 (2014). Retrieved February 25, 2015, from http://lib.dr.iastate.edu/ece_books/1

Bennett, S., Maton, K., & Kervin, L. (2008). The 'digital natives' debate: A critical review of the evidence. *British Journal of Educational Technology, 39*, 775–786.

Borgmann, A. (2006). Technology as a cultural force: For Alena and Griffin. *The Canadian Journal of Sociology, 31*, 351–360.

Brok, L. S. (2014, June 15). *Hvad gør lærere med teknologi i skolen?* [What do teachers do with technology in schools?]. Unpublished paper.

Creswell, J. W. (2009). Controversies in mixed methods research. In V. Knight & S. Connelly (Eds.), *Research design: Qualitative, quantitative, and mixed methods approach* (pp. 269–283) (3rd ed.). Thousand Oaks, CA: Sage Publications Ltd.

Cuban, L. (2001). *Oversold and underused computers in the classroom*. Cambridge, MA: Harvard University Press.

Dakers, J. (Ed.). (2014a). *Defining technological literacy: Towards an epistemological framework* (2nd ed.). New York, NY: Palgrave Macmillan.

Dakers, J. (Ed.). (2014b). *New frontiers in technological literacy: Breaking with the past*. New York, NY: Palgrave MacMillan.

Davies, C., & Eynon, R. (2013). *Teenagers and technology*. London: Routledge.

Dugger, JR, W. E., Jr (2001). March). Standards for technological literacy. *Phi Delta Kappan, 82*, 513–517.

Fragtrup, D., & Burlin, C. (2015, June). *Teknologiforståelse blandt lærer- og sygeplejerskestuderende. Opsamling af kvantitative resultater*. Retrieved from http://www.teknologisk.dk/projekter/projekt-styrket-teknologiforstaaelse-blandt-laerere-og-sygeplejersker/30323?cms.query=technucation

Gamire, E., & Pearson, G. (Eds.). (2006). *Tech tally: Approaches to assessing technological literacy*. Committee on Assessing Technological Literacy, National Academy of Engineering, National Research Council. Washington, DC: National Academy Press.

Geck, C. (2006). The generation Z connection: Teaching information literacy to the newest netgeneration. *Teacher Librarian, 3*, 19–23.

Hammersley, M. (2006). Ethnography: Problems and prospects. *Ethnography and Education, 1*, 3–14.

Hasse, C. (2015). *An anthropology of learning: On nested frictions in cultural ecologies*. Dordrecht: Springer.

Hasse, C. (2016). Learning matter. The force of educational technologies in cultural ecologies. In K. Scantlebury & C. Milner (Eds.). *Material practice and materiality: Too long ignored in science education*. Hamburg: Springer Verlag (in print).

Hasse, C., & Brok, L. S. (Eds.). (2015). *TEKU modellen—Teknologiforståelse i professioner* [The TECS-model—Technological literacy in professional work]. København: University Press.

Hasse, C., & Trentemøller, S. (2009, January). The method of culture contrast. In J. Motzkau, M. Nissen (Red.), L. L. Mørck, L. Huniche (Eds.), & A. M. Jefferson (Eds.). *Qualitative Research in Psychology, 6*, 46–66.

Hasse, C., & Wallace, J. (2012). *Towards a reconsideration of technological literacy*. Retrieved from http://technucation.dk/en/concepts/technological-literacy/

Helsper, E. J., & Eynon, R. (2010). Digital natives: Where is the evidence? *British Education Research Journal, 18*, 503–517.

Hicks, S. D. (2011). Technology in today's classroom: Are you a tech-savvy teacher? *The Clearing House, 84*, 188–191.

International Technology Education Association. (2000/2007). *Standards for technological literacy: Content for the study of technology*. Reston, VA: ITEA.

Jameson, F. (1991). *Postmodernism, or the cultural logic of late capitalism*. Durham, NC: Duke University Press.

Karsenti, T., & Fievez, A. (2013). *The iPad in education: Uses, benefits, and challenges—A survey of 6,057 students and 302 teachers in Quebec (Canada)*. Montreal, QC: CRIFPE.

Kristensen, H. V., & Johannsen, L. W. (2012, September). *Teknologiforståelse blandt lærer- og sygeplejerskestuderende. Survey af anvendelser, holdninger og forudsætninger*. Tåstrup: Teknologisk Institut.

Krupczak, J., & Blake, J. (2014). Distinguishing engineering and technological literacy. In Bassett, G., Blake, J., Carberry, A., Gravander, J., Grimson, W., Krupczak, J. Jr. … Riley, D. (Eds.), (2014) *Philosophical perspectives on engineering and technology literacy, I. Electrical and computer engineering books*. Book 1 (2014) (pp. 2–3). Retrieved February 25, 2015, from http://lib.dr.iastate.edu/ece_books/1

Luppicini, R. (2005). A systems definition of educational technology in society. *Educational Technology & Society, 8*, 103–109.

Molenda, M., & Robinson, R. (2008). Values. In A. Januszewski & M. Molenda (Eds.), *Educational technology: A definition with commentary* (pp. 241–258). New York & London: Lawrence Erlbaum Associates.

Organisation for Economic Co-operation and Development. (2015). *OECD digital economy outlook 2015*. Paris: OECD Publishing.

Organisation for Economic Co-operation and Development. (2016). *An OECD horizon scan of megatrends and technology trends in the context of future research policy*. Copenhagen: OECD Publishing.

Pearson, G., & Young, A. T. (Eds.). (2002). *Technically speaking: Why all Americans need to know more about technology*. Committee on Assessing Technological Literacy, National Academy of Engineering, National Research Council. Washington, DC: National Academy Press.

Petrina, S. (2003). The educational technology is technology education manifesto. *Journal of Technology Education, 15*, 64–74.

Petroski, H. (2010). *The essential engineer: Why science alone will not solve our global problems*. New York, NY: Vintage Books: A division for random house.

Prensky, M. (2001). Digital natives, digital immigrants. Part 1. *On the Horizon, 5*, 1–6.

Roblyer, M. D. (2005). Educational technology research that makes a difference: Series introduction. *Contemporary Issues in Technology and Teacher Education, 5*, 192–201.

Voogt, J., & Knezek, G. (2016). Guest editorial: Technology enhanced quality education for all – outcomes from EDUsummIT 2015. *Educational Technology & Society*, *19* (3), 1–4.

Wallace, J. (2011). *Technological literacy seminar 16 May 2011 DPU—A review of definitions.* Technucation/ Aarhus Universitet. Retrieved from http://edu.au.dk/fileadmin/www.dpu.dk/e-boeger/OL/Working_papers/Technological_Literacy_Seminar_16_May_2011_DPU_-_A_review_of_Definitions.pdf

Wallace, J., & Hasse, C. (2014). Situating technological literacy in the workplace. In J. R. Dakers (Ed.), *New frontiers in technological literacy: Breaking with the past* (pp. 153–164). New York, NY: Palgrave MacMillan.

Yawson, R. (2010). An epistemological framework for nanoscience and nanotechnology literacy. *International Journal of Technology and Design Education*. doi:10.1007/s10798-010-9145-1