

21-century learning skills revisited - a conceptual paper on leaving 'gaps' and going deep.

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Abstract

This paper revisits the 21st-century learning skills (21CLS) and discusses the need to leave 'gaps' in the curriculum while pursuing chosen topics more in-depth. The paper suggests ways to choose both 'gaps' and in-depth topics; furthermore, the paper investigates relevant technologies for bridging the gaps and for going deep. The paper discusses the connection between 'Das Exemplarische Prinzip' (exemplary teaching) and what may be interpreted to be the initial thoughts behind the formulation of the 21CLS presented in the document 'A Nation at Risk'. The two concepts are separated by three decades (1951 'Tübinger resolution -1981 'A Nation at Risk'). However, they share the same conviction that not every bit of knowledge available can be taught/learned and, furthermore, that some knowledge is more important than other. We wish to revisit this notion because we believe that the advances in Artificial Intelligence (AI) and the automation of increasingly complex processes in our everyday lives will influence education. This indicates that we may need to adjust the topic- and activity-selection principles that teachers and curriculum developers deploy to select what to teach and what to outsource to networked learning and digital learning materials. The discourse of the 21CLS seems to have materialised into a specific practice in Denmark, a practice that embraces programming exercises (Dot/Dash, LEGO Mindstorms, Scratch, Python etc.), tinkering with electronics, playing computer games, 3D printing and Laser cutting in workshops called 'Maker spaces'. The 21CLS, in a Danish context, are distilled into; Collaboration, Critical Thinking, Creativity, Communication (the 4Cs). In our research and in the development projects in schools we have taken part in, we have the positive experience that the way the 21CLS are practiced in a Danish context gave some pupils a sense of pride in their products and that some pupils acted more as designers of solutions for real problems than as pupils doing school work. On a more negative note, the 21CLS activities may come across as isolated events with little connection to curriculum or exams. Finally, we raise the discussion of how Teacher Education can develop a practice that incorporates the convictions of the 21CLS in other ways. We suggest a focus on technology that supports dialogue and reflection and bridges both knowledge 'gaps' and time and space 'gaps'. Furthermore, we suggest learning designs that revisit 21CLS as a framework for learning to learn.

Keywords

21. Century learning skills, Teacher Education, educational dialogue, learning designs,

Introduction

For the past 5 years schools, colleges, municipalities and universities in Denmark have created 'maker spaces' or 'fablabs' (fabrication laboratories) (AAU, ; UCC, ; UC Denmark,). That is workshops for tinkering with technology with the purpose of connecting a virtual design process on a computer with an actual process of producing physical artefacts. These labs appear to have a motivational effect on certain pupils/students (Sørensen, 2016); however, the long-term effects of working with 21CLS within the confinements of a 'maker space' or a 'fablab' seem less evident. In the national research project 'Student productions and student involvement' (2013-2016) (Sørensen, 2016) we investigated the implications of working with digital production in several scenarios and while some activities worked better than others the general experience was that making digital products motivated some students and that it in some cases fostered a negotiating dialogue amongst the students. However, we also experienced that the quality of the products and the conditions for learning from working on the digital productions relied on how well prepared and competent the students were. We experienced that if the digital production was used as a way of actualising pre-taught academic content, then the digital production became part of a fruitful learning process, whereas if the digital production was detached

from a more substantial course than it acted as an isolated event. This experience resonates well with this paper's three core inspirations; a quote from Wagenschein, the document 'A Nation at Risk: The Imperative for Educational Reform' and a quote from Trilling and Fade. It raises the question if it is time to revisit the core topics in the 21CLS and refocus the work with 21CLS (in a Danish context at least) to be more about developing digital learning competencies and getting fundamental knowledge than about scratching the surface of technologies that may be forgotten in a few years' time.

Method

This paper is a conceptual paper that joins key educational discourses. The analysis draws on the findings and experiences of two larger research projects (Sørensen, 2016; Caldwell, Bruun and Kjærgaard Thomas, 2016) and two local development projects at University College North (UCN). The main forms of reasoning are retroductive and abductive reasoning (Peirce, 1998; Chiasson, 2005; Bhaskar, 2008; Laursen, 2017), which in short means that we analyse the mechanisms that made a phenomenon occur and that we use that knowledge to form new ideas and speculate in directions for the future. Inspired by David Scott's research into Critical Realism and education (Scott and Usher, 2011; Scott, 2013) we see similarities between a researcher doing a retroductive analysis and a detective trying to solve a crime. In the sense that, as the detective, we are more interested in how or why a crime/phenomenon was committed/emerged than in the actual crime/phenomenon itself. Therefore, we do not investigate 21CLS as such we analyse how/why the 21CLS came to be represented the way they are and, furthermore, how we can develop more fruitful suggestions for the future.

Retroduction - looking at why the 21CLS materialised the way they did in Denmark

We believe that the National Strategy for Digitalisation 2011-2015 (Danish Government, 2011) (amongst other policies) pathed the way for the way for the materialisation of the 21CLS in Denmark. The strategy suggests that schools should be increasingly digital and that schools should prepare the pupils/students for a digital future. The strategy was funded by two 500'000'000 kr. pools to subsidise the development of digital learning materials and to invest in technology in schools. This led to an increase in digital technology in schools. The general notion in the strategy is that digital learning materials are quicker, easier and more efficient than analogue learning materials. The strategy also suggests that digital learning materials will free time for the teacher. Therefore, the strategy implies that technology in education should be efficient, quick and aimed at the needs of the future. Therefore, the learning materials and the practice of the 21CLS follow the same line of thinking. That is, easy production in fab-labs, easy programming in Scratch, easy tinkering with electronics. None of the key points in the strategy suggests the more tiresome focus on learning to learn in digital networks or the daunting task of accepting that learning is hard. In other words, the 21CLS became represented through hardware and gadgets and not so much as a philosophy for learning.

Abduction - formative experimentation

Following our retroductive analysis, we created a set of criteria for 21CLS learning designs presented here.

Inspiration

The first inspiration is the quote below, Wagenschein expresses his notion of how to leave gaps and instead address the original fundamentals (own translation):

'No one knows if we in 50 or 100 years' time will shake our heads or smile. If we do, it is probably because of a school that believed in the possibility gaining something through accumulating 'half learned' knowledge while assigning it an absolute value. 'The courage to leave gaps' we said in the beginning [of the article]. It is easily misunderstood. What we meant was the courage to be thorough, the courage to seek the fundamentals. Instead of the broad and static perfection ideal, which anxiously fills our pantry, we were looking for something else, a resolute breakthrough to the original sources. Not the completeness of the latest results but rather the inexhaustibility of the originals.' (Wagenschein, 2012p: 64)

The quote dates back to 1956 and it raises the question of what/how to teach and what/how not to teach in the German schools. Even though, the quote is more than 60 years old the issue that it deals with seems even more relevant today. The notion that we can get information about almost anything, almost anywhere makes it even more important to create an educational framework within which certain information is important and other information is less important. This issue is also brought on by a paradigmatic shift from input guided teaching

(curriculum) to output guided teaching (learning goals) in the sense that having a canonised curriculum delineates the topics for the lessons (Danish high schools up till 2005 and schools up till 2013 and Teacher Education up till 2013). In learning goal guided teaching many different paths may lead to a learning goal, which has led to teacher students finding it difficult to identify what they are, actually, learning. A senior teacher-student put it this way:

'I feel as if I have four weak arms and no skeleton' (senior student, Teacher Education)

The quote exemplifies what Wagenschein refers to as 'accumulation of half-learned knowledge' (Wagenschein, 2012p: 64). The student elaborates that he has been introduced to the topic of 'inclusion' in four different courses without really learning how to teach with inclusion in mind or what the original intentions and ideas of 'inclusion' were. This experience in teacher education resonates with the experience in schools, where the pupils may be introduced to, for instance, programming and computational thinking without actually getting into a more long-term study of coding. The technologies that are used to promote 21CLC. Century learning skills seem to scaffold the experience so extensively that it may become to recognise what the pupils are actually learning.

- Do pupils learn to programme from LEGO Mindstorms?
- Do pupils learn about robots from Dash/Dot (Small robots)?
- Do pupils learn about 3D modelling from using a 3D printer?
- Do pupils learn about video editing from using iMovie on an iPad?

The above-mentioned technologies may have other beneficiary implications on the pupils such as training design thinking, negotiation skills in peer-dialogues, motivating pupils and the immediate joy of doing something new and fun (Sørensen, 2016). However, we experience that the pupils do not learn to programme, they do not get an understanding of robots and the future of artificial intelligence, they do not learn the techniques of 3D design and they do not learn how to create a vertical montage in a video editing. Therefore, we wish to re-address the questions from the questions from Wagenschein:

- What should pupils and students learn?

The second inspiration is the report 'A Nation at Risk The Imperative for Educational Reform' (Gardner, 1983). The document was an open letter to the American people from the Secretary of Education and the United States Department of Education putting forth a series of concerns for the future of the wealth of the USA. The report is included as an inspiration for this paper because it addresses how technologies may influence education. The report predicts (Gardner, 1983 p: 18):

- Computers and computer-controlled equipment are penetrating every aspect of our lives--homes, factories, and offices.
- One estimate indicates that by the turn of the century millions of jobs will involve laser technology and robotics.
- Technology is radically transforming a host of other occupations. They include health care, medical science, energy production, food processing, construction, and the building, repair, and maintenance of sophisticated scientific, educational, military, and industrial equipment.

The report substantiates Wagenschein's notion that a conscious choice of what to teach is increasingly important. Furthermore, the report adds the effect of developing technologies as an important factor in future curriculum designs. Therefore, we add the presumed effect of AI and digital technology in education to the question of what to teach:

- What should be taught face-to-face and what could be designed in virtual learning processes in digital learning designs?

The third inspiration for this paper is a quote from Trilling and Fadel's book '21st-century skills: Learning for life in our times' (Trilling and Fadel, 2009). Trilling and Fadel address knowing a subject's fundamentals to solve problems as central to what to teach in schools today:

'Yet knowing a field's core ideas, understanding its fundamental principles, and applying this knowledge to solve new problems and answer new questions are evergreen learning tasks that will

never become outdated. These learning skills need to move to the heart of what our schools teach.' (Trilling & Fadel, 2009 p: 26)

Trilling and Fadel's claim is that pupils and students should acquire a subject's essential knowledge and learn to apply knowledge to solve problems. This leads to the questions:

- How can teachers determine a field's core ideas and fundamental principles seen in relation to recent years advances in AT and digital technology in general?
- How can teachers create learning designs that give a strong scaffold for knowledge-based problem-solving?

The three inspirations for this paper has led to the four questions raised above. We will now look into how it seems as if 'maker spaces' and 'fab-labs' in a Danish context are motivated by the idea that they may represent plausible answers to four questions. We will also look into alternative answers to the four questions.

Analysis of inspiration

We interpret Trilling and Fadel's statement above to resonate well with Wagenschein's exemplary principal (Wagenschein and Horton-Kriiger, 2000) and with the 'A Nation at Risk' report (Gardner, 1983). We read a linear progression into the three texts that go from acknowledging a 'congestion of themes' to an awareness of changes in what to learn and how to learn to, lastly, an awareness of how computers may do part of the thinking for us.

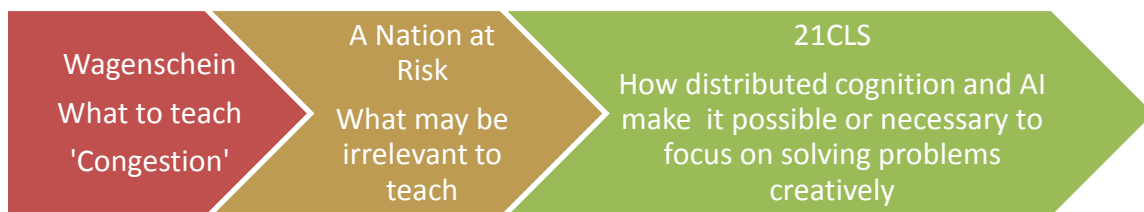


Figure 1 Progression of what to teach and learn

In that respect, the 21CLS may be interpreted as an answer to the questions that Wagenschein and 'A Nation at Risk' raise. If designing solutions based on knowledge is at the core of what students should learn then makerspaces and fab-labs could seem like learning spaces, where designing processes could be learned. However, what we have experienced in the projects we are engaged in (Sørensen, 2016; Caldwell, et al., 2016; UC Denmark, 2017) is that the design process often is detached from the field's core knowledge and, furthermore, that the design process does not contribute to the students building of the field's core knowledge. Bearing in mind that the learning goal is more than learning to design.

We would like to address another aspect of 21CLS, which is the 'learning to learn' because it is our experience that this agenda has been pushed aside by a strong focus on maker-spaces, fab-labs etc.

As mentioned in the introduction the 21CLS are narrowed down to, robotics, gaming, electronics, programming, maker space and digital production (UC Denmark, ; Ministry of Education,). We have extracted what appears to be the protruding 'action verbs' of the 21CSL discourse in the projects that we are engaged in. They are to tinker, to develop, to create, to communicate, to collaborate, to innovate, to design, and to some extent also to analyse. All of these verbs could be argued to adhere to higher orders (Anderson, et al., 2001) of learning, which indicates that the 'verbs of the 21CLS' represent complex competencies we will need in the future rather than basic skills. The practice of the 21CLS, as we interpreted them, are mainly focusing on getting basic skills to produce artefacts and in the cases that we have studied the practice focus less on reflection (Caldwell, et al., 2016; Sørensen, 2016; UC Denmark, 2017). This may lead to a superficial practice of 'output without input', which in turn could lead to 'event pedagogy'. The notion of 'event pedagogy' describes a situation where the activity is a self-contained unit that only vaguely connects to the subject of teaching and, thus, doesn't give insights to a subjects core principals and fundamental knowledge.

In many ways 'the event' may be a positive variation of the teaching in schools or at teacher education, however, when the experience of 'the event' represents the digest of the students understanding of what 21CLS are, then we may miss out on what the 21CLS are also addressing.

Choosing content

Wagenschein's exemplary teaching (Wagenschein and Horton-Kriiger, 2000) and Klafki's categorial education 'kategorial bildung' (Klafki and Nordenbo, 1983) form a framework for selecting what to include in the curriculum and what to leave out. Wagenschein's idea is that the subjects for teaching should be, elementary,

fundamental and exemplary. In this line of thinking 'elementary' means that the subject is built from parts that can be dealt with individually. 'Fundamental' means that the subject acts as a foundation for other subjects and, finally, 'exemplary' means that subject is recognisable as a representative of the subject.

In accord with that, Klafki develops the notion of 'categorical education' (Klafki and Nordenbo, 1983; Davidsen, 2015 p: 5), which relies on six 'core problems of the modern world'. The core problems that Klafki formulate are peace, environmental issues, socially created inequalities, effects of new technologies/intercultural education, I-You-relationships. Therefore, if we combine Wagenschein and Klafki we get a series of suggestions of what to include in the lessons.

If we analyse the subject of, for instance, programming in the light of Wagenschein and Klafki we may conclude that programming is an important subject for learners in the 21st century.

- Programming is elementary; you can start simple and end up advanced.
- Programming is fundamental in the sense that it represents unique methods for making microprocessors act out commands upon which you can build user interfaces.
- Programming can be exemplary if you choose a language of programming that actually resembles the language that microprocessors operate by
- Programming does address that Klafkian 'core problem' of 'effects of new technology'

However, in the practice of the 21CLS programming is not exemplary or fundamental. It becomes a new entity that neither is a typical example of what programming is nor is it a foundation for exploring programming further. Thus, the real problem is not that we do simple programming in schools and at teacher education; the real problem is that we only do simple programming. Actual programming competencies requires knowledge, skill and time and, assumedly, only a few students will need programming competencies in their future careers, thus it could make simple programming of robots or in Scratch redundant.

Technological literacy

A reason for introducing the canonised selection of technologies that has become precedence in Denmark (Lego Mindstorm, Robots, block electronics, 3D printing, Laser cutters, Scratch etc.), that goes beyond the technologies themselves, could also be to develop technological literacy. Inspired by the Technucation project (Arstorp, 2015; Hasse, et al., 2015) from Århus University and for the purpose of this paper technological literacy is defined as:

A technologically literate person understands the significance of technology in everyday life and the way in which it shapes the world".(International Technology Education Association, 2007 p: 33)

Then the technologies serves as exemplary cases intended to show how a selection of simplified digital technologies may work. However, later studies in technological literacy suggest that the interaction between humans and technologies and the interaction between humans through technologies is also significant part of being technologically literate (Ingerman and Collier-Reed, 2011).

We believe that the latter part of technological literacy is more important than the first, even though, the one presumably needs the other, as is suggested in the research of Castells, Martin et. al. (Castells, 2000; Martin and Madigan, 2006). This brings topics such as how to interact with digital communities and how to 'learn with strangers' (Dron and Anderson, 2014) on the agenda. In the Danish context of 21CLS this is not a protruding topic, communication skills are mainly described as presentation skills (UC Denmark,), which is also very important, conversely, not necessarily a 21CLS.

Technology and the 21CLS - new conditions for learning

For the purpose of this paper, technology can be defined as;

'a system created by humans that use knowledge and organization to produce objects and techniques for the attainment of specific goals' (Volti, 2005 p: 6).

Furthermore, that ' knowledge of technology allows one to distinguish between what is natural (i.e., not technology) and what is made by humans (i.e., technology)' (Carroll, 2017 p: 126). The word, technology, stems from ancient Greek, where it means the 'science of craft'. In the context of education, educational technology may be defined as means to enable 'creating, using and managing' (Januszewski and Molenda, 2013 p: 6). In the discourse of 'Actor-Network Theory' (Latour, 2005) technology may have agency and is, thus, prone to effect

changes that go beyond what the human developers had imagined. When we analyse 21CLS we understand technology as:

'Manmade means to change the conditions for life created with a purpose and, potentially, with agency beyond what we intended.'

The understanding of technology in the local (DK) discourse of 21CLS seems to concentrate on technology that enables us to create and produce things and less on which conditions have changed or will change. When we regard technology as 'manmade means to change conditions for something', then the question is, which conditions are changed in education, or which conditions do we want technology to support the change of? On a macro level education is still organised as it was in the earliest 'state schools' (1814 Act on Compulsory Education) in Denmark. That is, one teacher, one classroom and a group (20-30) of pupils/students facing the blackboard. Situated in a school, college or university of classrooms. Only to add spite to injury the size of the classes (20-30 students) are the least advantageous relation between group size and learning outcome according to several studies (Glass and Smith, 1979; Hattie, 2005; Monks and Schmidt, 2010; Schanzenbach, 2014). Therefore, we suggest that when we add technology to education it could potentially be to change conditions and circumstances for learning. Thus, the purpose of the introduction of technologies to education is not only to do technology-rich activities in the same organisation for teaching that we have known the past 200 years. The purpose could be to reorganise teaching differently and to utilise technology to distribute information and form knowledge networks. Therefore, the important question to ask is:

- Conscious introduction of technology: Which conditions should technology change in teaching or learning?
- Retrospective reflections on the presence of technology: How does the conditions for teaching or learning change when technology is introduced to education?

Organising teaching in accord with Wagenschein, Klafki and the 21CLS

If we hone in on the idea of using technology to develop a deeper knowledge of a subjects core ideas we could develop other ways of organising education (school, college and university). This way 21CLS are redefined as principals for learning in the 21st century and not as decrees of competences (the 4C's). This leads to an interpretation of the 21CLS that focus on utilisation of digital networks and digital resources to enter into independent learning processes and to contribute to communities of practices and wider networks of learning. It also addresses 21CLS as a strategy for deep learning (Kjærgaard, 2015). That is a strategic utilisation of dialogic technologies for deep learning, which in the concrete practice of the experiment that this paper reports from means, online discussion, hashtags in Twitter, YouTube, student response systems (e.g. socrative).

In an ongoing developmental experiment at Teacher Education (UCN) this led to an intentionally reductionist dogma for teaching that reads:

- 1 'Pedagogical ideal': Formulate a 'pedagogical ideal' for the topic. Students, lecturers and programme directors should share the 'pedagogical ideal'. The core principals and fundamental knowledge.
- 2 Holes: Identification of what to leave out of the lessons and displace to digital learning designs. All that can be excluded from the lesson should be excluded in accord with the 'pedagogical ideal'
- 3 Filling holes: What is excluded should be re-imagined and re-mediated into other modalities in digital learning designs that the students engage in independent for the teacher's interference.

These dogmas were presented at Danmarks Læringsfestival 2017 and now they are giving direction to a development project called 'Personal learning networks' at Teacher Education UCN. These dogmas entail three points of interest:

- What is the 'pedagogical ideal' for this subject, how do teachers create the best conditions for learning this subject?
- Which literacies will the students need to successfully engage in digitalised and independent/peer-group learning designs?
- Which literacies will the teachers need to create digitalised learning designs that rely on independent or peer-group learning?

In the investigations that this paper reports from, we set out to find what the students regard as the most important part of the learning process in the 21st century. The students and lecturers (426 students and 56 lecturers at Teacher Education UCN) reported that 'dialogue' in smaller groups (4-7) was the shared 'pedagogical ideal' amongst academic staff at teacher education (Kjærgaard, 2016a; Kjærgaard, 2016b). 'Dialogue was defined as 'thinking together through language' (Littleton and Howe, 2010).

In that sense, the 'holes' that we leave in the syllabus make way for more dialogue in smaller groups and the technologies that create the conditions for the dialogues are technologies that augment human interaction at a distance.

This 'pedagogical ideal' of dialogue and the displacement of other learning activities rely on the students' competencies for learning independently and in communities. In turn, this demands a learning design that scaffolds students' development of independent strategies and competencies for learning. We regard the competency to learn independently and in communities of peers through the means of digital networks, videos and discussion as very important learning skills in the 21st century. Thus, we venture into contested discourses, which seek to redefine teaching to be more about creating a pedagogical scaffold for learning than about instruction and presenting academic topics.

Conclusion

We suggest that we re-visit the 21CLS in a quest for deep learning strategies and in a quest for a fundamental discussion of what necessitates human, physical interaction in a learning process (teacher/student) and what might be designed in partially automated, digital learning environments. We suggest that Wagenschein's principals for exemplary teaching could be used to select what to teach, physically, and what to create a digital learning design for. We also suggest a discussion of, which pedagogical decisions could be made by AI in the near future and which should still be made by teachers. If the end goal in education is to develop creative, critically thinking, communicating and collaborating students, then our suggestion is that we focus our face-to-face lessons on scaffolding interactions that foster these end goals instead of spending lessons on conveying information and doing drills and training that the students may as well do between lessons.

The combination of a human, unpredictable element in the lessons and an inhuman/programmed element of the pre- and post-lesson phase make a scaffold for learning that relies on both human and digital traits. We, the human teachers, do not try to outdo computers when it comes to; finding and presenting information, or memorising data, or documenting processes, or doing meticulous repetition etc. However, we do insist that well-scaffolded empathetic, dialogic and reflective conversations in smaller groups are the key when it comes to deep learning.

When we make learning designs according to the three dogmas mentioned above (deliberate a pedagogical idea, only leave in what cannot be taken out, create a digital scaffold for everything else) the lessons become plateaus of intensities (Deleuze and Guattari, 1987). That is, vibrant communities of practice that demand full attention from the students, which results in lessons where you cannot hide in the back row or skimp out unnoticed. The digital strand of the course make the students' engagement explicit through statistics in the LMS and the dialogue in the lessons gives a qualitative impression of the student's engagement, which in turn makes this type of learning design more demanding on the students than traditional courses.

Therefore, the digest of the investigations and analysis in this paper is to remind us that 21CLS is also about developing new ways of learning and new ways of organising education.

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