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Challenges in Educating Student Art Teachers in Technology Comprehension

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Abstract: This paper focuses on a study of what teaching competences technology comprehension requires (TC) for teacher education. The background for the study involved a national initiative about developing TC as a teaching subject and integrating it into the existing Danish school curriculum. To follow up on a large-scale national experimental project in primary schools, the ministry launched a small-scale qualification project to promote this integration and develop teacher educators' competences. The project involved teacher educators representing several school subjects, including visual arts, which was the scientific object of the study in this paper. The qualification project was framed as a network process with research input and peer discussions of learning designs among a group of 20 researchers and 40 teacher educators. The teacher educators applied their produced designs as a part of the ordinary curriculum for teacher education, with two interventions at their home university and shared experiences with the group. This paper reports these interventions. The theoretical framework of the study drew on subjects related to visual arts education, TC theory and social material insights. As part of the larger qualification project, the methodological approach employed design-based research (DBR). The study demonstrated how the implementation of TC in an existing teaching subject became a negotiation between the teaching subject, the students and the teacher regarding how to integrate a new aspect of professionalism into visual arts education. When incorporating elements from computer science into visual arts education, the levelling of two different paradigms are crucial. Although digital technology has been a tool for practicing visual arts for 20 years, both students and teachers found it difficult to implement programming and computational thinking elements and maintain the art focus. This created a new challenge for the art teacher, who was forced to develop re-conceptualisation skills by converting programming into hacking activities and thereby facilitating the students' artistic approach to TC.

Keywords: technology comprehension, student teachers, visual arts, programming, teacher educators

1. Introduction

This paper addresses the current discourse surrounding how students achieve relevant programming and computational thinking competences to tackle current and future societal challenges from the perspective of visual arts education. Although digital technology has been a component of Danish school subjects for years (e.g. Caeli & Bundsgaard 2018), a renewed focus on computational thinking and programming emerged and became a ministerial focus area in the Danish education system in 2018. This paper seeks to address the following questions: First, how should this be taught in a manner that effectively prepares students for meeting future societal challenges? Second, what are the relevant competences? Is it a matter for computer science? Is it a task for the so-called STEM disciplines already familiar with the computer science paradigm? Alternatively, should it instead include disciplines from the humanities? By launching a concept of computer science as a problem-solving competence, scholars such as Jeanett Wing (2006) have established a broader agenda for the subject to concern several educational disciplines and to apply to real-life problems. Wing argued that computational thinking should be regarded as a particular language of the future necessary to take on a career. Thus, computer science was asserted to be a transdisciplinary skill that concerned other disciplines in schooling. In Denmark, an expert group formulated a syllabus to obtain the necessary computer science skills by combining programming and computational thinking skills with designing activities and digital empowerment (Ministry of education 2019, Wagner et al 2020). The ambitious goal was to integrate computer science and the humanities into a new hybrid for schooling. The general approach using the term TC became the starting point for a ministerial focus area in both a national school experiment and a national further education project regarding teacher educators in Denmark from 2018 to 2021. The major question that arose concerned whether this new construction of TC should be practiced as a new and separate discipline or as an integration of existing curriculum disciplines. The ministry decided to attempt both a national school experiment and a qualification project involving teacher educators. The present study presented in this paper was part of the qualification project that concerned teacher educators TC in visual arts education. The research interest concerned how the teacher educator and the student visual art teachers negotiated TC as a new addition to the visual arts curriculum.

1.1 Background: The study as a part of a larger initiative

The national initiative to develop TC as a teaching subject to be integrated into the existing school curriculum in Denmark was launched in 2018 and applied to 1st to 9th grade in 46 schools (Ministry of Education 2018) in which visual arts education constituted one part (Buhl 2019, Buhl & Skov 2020). Prior to an experimental project[1], elements from the TC syllabus were added to the national curriculum for visual arts education from 1st to 3rd grade (Ministry of education 2019b). Based on the expanded national curriculum, project participants, being professionals in the field, developed six prototypes (Buhl & Skov 2020, 2021). The prototypes tested by schools participating in the project and their feedback informed the project developers' further reflections and contributed to the overall project (Buhl & Skov 2021).

Parallel with the large-scale national experimental project in primary school where learning content was developed, tested and evaluated, the ministry also launched a small-scale qualification project that intended to promote the implementation process for technology comprehension. The qualification project aimed to contribute to the conceptual development of TC and to simultaneously provide teacher educators with competencies to educate the future workforce of teachers for primary school. The project participants represented the singular subject of TC and three existing school subjects including visual arts education. The qualification project was framed as a design, intervention and evaluation process drawing on insights from design-based research (eg. Barab & Squire 2004, Amiel & Reeves 2008), organised in network meetings where 20 researchers and 40 teacher educators gathered and shared general and subject-specific research input through peer discussions and idea development for their own learning designs. The teacher educators tested their designs in two rounds (two x four hour) of interventions with student teachers at their home university. The interventions were conducted as part of the ordinary curriculum for teacher training, and the results were shared and discussed afterwards in the network. The present study reports how the two learning designs were met by student teachers in visual arts education based on data from the two interventions and with an interest in what occurred when a teaching subject in the humanities adopted the TC construction. The purpose was to illuminate visual learning potential and challenges to be able to discuss to what extent visual arts education might contribute to the overall ministerial agenda regarding a cross disciplinary approach to digitalisation and not least to discuss the potential in using TC as a renewal of visual arts education content.

2. Research design

The study focused on the part of the development project concerned with the trial implementation of two learning designs located at University College Copenhagen (UCC). In Denmark, teacher education for primary school is a four-year-long general programme. During the programme, the student teachers select four school subjects in which they specialise. The school subject visual arts education is one of these specialisation tracks, in which the student teacher has agency to select their subjects. The visual arts teacher track trains future visual arts teachers for primary school (1-9 grade). While the ministerial experimental project focused on implementing TC in schools between 1st and 3rd grade, the competence development project of visual arts teacher educators adhered to a broader perspective concerning how student visual arts teachers can be prepared to teach it in primary school.

The study aimed to reveal potential benefits and challenges of employing a digital technology integrated learning design in a visual arts education class based around the structure of the overall qualification project. This structure offered two iterations of a learning design developed and attempted by the visual arts educators at their home university and followed by new reflections with peers. This pedagogical intervention was integrated as part of the ordinary curriculum with a duration of eight hours each, one in the fall of 2020, and one in the spring of 2021. Two groups of student visual arts teachers (16 and 13) participated in the implementation of the learning designs. The first learning design was a 3D-modelling assignment using the software app Tinkercad. Informed by this first iteration, the second learning design was a video hacking assignment.

In the study of the implementation of the two learning designs, the arts teacher educator and the researcher formed a collaboration and conducted the process inspired by the research principles from design-based research (eg. Barab & Squire 2004, Amiel & Reeves 2008). The problem identification was based on research in digital technology and visual arts education (Kiefer-Boyd 1996, Knochel & Patton 2015, Buhl 2019, Buhl & Skov 2020, Buhl & Skov 2021), and it was informed by discussions with peers. This comprised the design principles for

[1] https://tekforsøget.dk/

the two iterations, which again involved discussions with peers before and after the pedagogical intervention. The empirical data consisted of learning design from the two interventions, including teaching plans and material, observations (two x four hours) such as photos and field notes, and oral and written student evaluations. Furthermore, co-researching oral evaluations between the educator and the researcher along with peer discussions in the development network before and between the interventions constituted a contextualisation of the observations. The observations took on a social material perspective in relation to the visual practices as hybrid assemblages of meaning-making. This notion of hybrid assemblages formed the empirical basis for the analysis of the social practices of art-making as well as the framework for understanding how the negotiation between art and technology was enacted. The empirical data from the intervention phase were approached and analysed from two perspectives. One perspective focused on how digital technology was entangled with other materialities in the student arts teachers' practices of meaning-making (Fenwick and Landri, 2012, Meyer 2016). This indicated how the designs were adopted as a means for art-making. The other perspective focused on how the students approached and engaged with the learning designs as curriculum. This indicated how the designs were negotiated in the collaborative processes and how the students and teachers attributed meaning to digital technology as a driver for renewing visual arts content (Wenger 2000).

3. Theoretical framework

The theoretical framework for studying the intervention with the two learning designs drew from subject-related theories developed in the field of visual arts education relating to digital technologies. The two learning designs tested in practice were anchored in Danish visual arts pedagogy generated by researchers in the field, where in a thematic outset forms the basis for art-making (eg. Buhl & Flensborg 2011, Pedersen 2004, Rasmussen 2017). The thematic framework promoted a pedagogical philosophy encapsulated in the German term Bildung (Klafki 2001) and represented visual art-making as a mode of promoting critical thinking and personal empowerment. This approach was renegotiated when the notion of visual arts education as social practice was added to the curriculum in 2009 through the term *visual culture.* This drew from scholars who boasted a new path towards visual practices drawing on contemporary arts currents and visual cultures to promote visual practices as interpreters and inventors in a rapidly changing world. This addition was consistent with international currents of developing a new and transdisciplinary approach to visuality that also included digital media (eg. Mitchell, 1994 2002, Sturken and Cartwright 2009). One analytical interest was how the thematic approach and technological practices were entangled and generated new meanings and art content. When TC was added to the national curriculum in visual arts education, this was seen in the historical context of the teaching subject. Technology's role in visual arts was a pendulum swing between a computer science-focused attention to programming to producing images digitally in the 80s, to a software attention to the use of image processing programs in the 90s, 00s and 10s (Buhl 2019, Buhl & Skov 2020, Buhl & Skov 2021). The early 20s have revealed a renewed attention to programming within computer science, reintroducing programming and computational thinking as key factors in TC and as means for art-making and societal education (Buhl & Skov 2021). The new perspective emerging from this re-entry to the school and teaching subject allowed the creation of tangible and intangible artefacts in a learning context. Furthermore, it permitted a renegotiation of the substance of the existing visual arts curriculum. Thus far, digital technology was comprehended as a tool for art-making in line with other tools such as a pencil, a brush, or a modeling stick. However, the increased accessibility to more digital devices, apps and advanced data processing challenged the tool-metaphor in the teaching of visual arts. This perspective formed another analytical interest in the study.

Knochel (2016) posited from an actor-network perspective that image-processing programmes are non-human didactics because they instruct students in how to perform visual actions. Inspired by Latour's (2005) actor-network-theory (ANT), his example adopted a broader perspective regarding how learning situations may be approached as a complex of social and material agency. On the one hand, image-processing programmes simulate recognisable analogue tools; on the other hand, they offer new and different production possibilities such as countless layers, multiple form manipulations and endless editing possibilities without destroying the material basis. Technology offers a new materiality and thereby new opportunities for art productions that might surface in situations of practice. Following the perspective of Knochel (2016), art-making could be approached as a social and material process with a new set of possibilities for visual production where digital technology was a co-productive partner. Fenwick and Landri (2012) contended that the agency of digital technology and other materialities challenge the well-established dichotomy between human intentionality and non-human objects. They suggest that this dichotomy must be overcome for a fuller understanding of learning processes, and their position supported Knochel's suggestion of the 'non-human didactic'. From this perspective, digital technology

not only offers new digital activity forms; it exposes the traditional means of thinking about arts learning practices in education and offers another manner of conceptualising the art-making process. The social material approach offers a perspective on art-making practices that involves both human and non-human agency in a continuous flow of events involving schedules, bodies, digital access codes, desks, phones, pencils, stories, chewing gum, course syllabus, bananas and electricity as actors in the meaning-making process. An art-making class with 3D modelling and video hacking performed in a physical and online environment forms a 'continuum of materials, ideas, symbols, desires, bodies, natural forces, etc. that are always active, always reconstituting themselves' (Fenwick and Landri 2012, p. 3). Fenwick and Landri proposed the term *hybrid assemblages* to describe how learning emerges from a continuous social practice of materialities of 'doing', to which meaning is attributed (ibid). In the present study, this notion of hybrid assemblages formed the empirical basis for analysis of the social practices of art-making as well as the framework for understanding how the negotiation between art and technology is enacted.

4. Analysis

This section presents the content combined with the key findings from the study's two interventions. The following elaborates on the analytical perspectives regarding how the learning designs were conducted as an entangled technology and art-making process, and as a negotiation with digital technology in meaning-making as an impetus for renewing visual arts content.

4.1 An entangled process of technology and art-making framed by two learning designs

Intervention 1: 3D modelling

The aim in the first pedagogical intervention was developing both the students' visual arts competences and their technological comprehension of the 3D modelling program Tinkercad. The main idea in the 3D modelling was to highlight a digital means of modelling as opposed to a traditional analogue 3D modelling method (e.g., using clay) and to approach it from the perspective of digital aesthetic and architectural skills.

The learning design consisted of the following:

- 1. Working on-site in an urban environment aiming to improve architectural and aesthetic qualities and ensure experiences with urban architecture through photo documentation and sketching ideas.
- 2. Introducing national and international artists working site-specific.
- 3. Introducing 3D modelling in architecture, art and design in general, and to the Danish visual artist Morten Modin[2] andhis artistic processes and reflections on digital 3D modelling.
- 4. Insights in TC in the Danish school pilot programme and in the subject of visual arts.
- 5. 3D modelling prototypes for the urban site and testing the visual aesthetics in relation to code blocks, programming and construction produced by student teachers.
- 6. Use an image processing app to install the prototype in the selected urban placement.
- 7. TC content focusing on digital empowerment, computational thinking and technological capacity.

The educational intention was to comprehend the technology through hands-on experiences by performing experiential and reflective visual art activities, which was an approach familiar to the students (e.g. Buhl & Flensborg 2011, Buhl & Skov 2021, Rasmussen 2017). Furthermore, another aim was to relate to their future working field as art teachers in school, where TC is a growing focus point, as this would make a relevant competence. Thus, the computational modelling process was established in line with an analogue modelling process, but this time using data rather than clay as material. The thematic outset was urban architecture.

While working in Tinkercad, the students were urged to investigate the possibilities for changing the code blocks and the resulting effect on the aesthetic visual output. After several experiments with different shapes, repetition, constructing with holes, and respectively with or without transparency, etc. in the prototypes, the art students were encouraged to creatively reflect on the actions' impact on the constructed code and the visual expression. They were to analyse the code blocks and their function in the algorithm and to examine the effect of re-ordering the code and to assess whether some codes were more important than others. This was meant

[2]Modin, Morten: https://www.mortenmodin.com/

to establish coherence with technological comprehension in terms of code blocking and construction as well as contribute to critical reflection about the pros and cons of using technology in art-making. To connect experiences from everyday fields, the students were asked to identify experiences similar to programming and construction (e.g., Minecraft or LEGO). Moreover, the students were instructed to construct a common professional visual arts and technology glossary to support awareness of a visual arts perspective and a technological comprehension perspective as well as possible crossovers between the two disciplines, such as displacement, principles of construction, etc. However, it turned out to be quite difficult for the students to understand the possibilities in Tincercad for changing the code blocks and the resulting effect on the visual output as the students instead perceived it as 'just' a possibility of designing visual arts as opposed to being a matter of technological comprehension as well. Most of the students had never used a 3D- modelling program. Furthermore, it was their first real encounter with the concepts and perspectives of technological comprehension. The timeframe of about eight hours determined by the overall project design did not leave them much space to reflect and to feel in charge in the process.

Intervention 2: Video hacking

Based on the experiences from the 3D modelling intervention, the second intervention was designed in a different manner, still concerning both the possibilities for developing the students' visual art competences and technological reflections. This time, the learning design addressed two technological assets as the thematic core for art-making in order to investigate how they could engender new art forms. Their use of technology was guided by aesthetic methods and interests.

The main idea behind *Video hacking* was to focus on BIG DATA and artificial intelligence (AI) in relation to art and to visual art as a subject in its own right. This was done in combination with introducing two Danish visual artists' aesthetic methods and reflections, through theoretical perspectives, and through students' own video works.

The learning design consisted in a combination of the following:

- 1. Introducing the Danish visual artists Christoffer Ørum[3] and Cecilie Waagner Falkenstrøm[4], their aesthetic methods and their reflections relevant for the topic of BIG DATA.
- 2. Artist talks and discussions with a museum director on BIG DATA and art generated via AI (streaming event).
- 3. Theoretical perspectives on TC by Fibiger (2020) and technology phantasy by Toft Nørgaard (2020).
- 4. The visual arts students' own video productions and video hacking related to performing and understanding pattern recognition in AI.
- 5. TC focusing on digital empowerment and computational thinking.

In groups, students were instructed to produce a video on the theme *Landscapes*. After having produced videos that reflected different perspectives regarding the theme, each group was asked to hack another group's video either by hacking a colour, a pattern or the soundtrack. First, the students had to closely watch another group's video several times before discussing possible systematics for hacking. What would be an interesting take from a visual arts perspective - a colour, pattern or a new soundtrack? The students were then instructed to make a few tests and determine whether the video worked visually, regarding sound or perceptually before disrupting the other group's video. Finally, when showing both the original and hacked video versions, the other students were asked to attempt to crack the code and reflect on what meaning the hacking could have for the experience of the video.

4.2 A negotiation with digital technology in meaning-making as an impetus for renewing visual arts content

The first intervention produced empirical data that situated the software app as a prominent material actor. To some extent, it played a role as a non-human co-instructor due to the programmed automation that offered the students actions buttons for blocks, surfaces and colours in a grid construction environment. As they entered

[3]Ørum, Kristoffer (2016): Art Talk (in danish): https://vimeo.com/166496451 & Ørum, Kristoffer: http://www.oerum.org/
[4]Falkenstrøm, Cecilie Waagner: https://www.ceciliefalkenstrom.com/

the app, the 'machine teacher' guided them towards activating its functions (Knochel 2016). This 'machine teacher' took over instructions on a machine level, and the art educator's role was to create the overall connection between the students and Tincercad's constructions and the urban and architectural theme. The students were provided a manual and asked to become acquainted with the functions of Tinkercad beforehand. Nevertheless, the production process was accessed with reservations among some students. Others appeared to have understood Tinkercad and experimented with diverse functions on screen. Approaching the Tinkercad, other materialities were observed to be involved in the hybrid assemblage as well (Fenwick & Landri 2012). For instance, paper and pen acted in relation to the tablet with parallel utterances. There were several turns where the paper acted as the supporter and scaffolder for the modelling activity or even as the constructor. The making processes were often interrupted by the students checking their phone or moving on the chair, leaving the room, eating bananas or fetching coffee. In terms of time spent, it cannot be traced which one was the key activity. Students appeared insecure around the art-making process on screen and involved several material co-actors in the process. Although the students were experienced users of technology in their everyday lives, the construction of an architectural artefact for the urban place was not terminated.

Invention 2 made it easier for both the students and the teacher educator to focus on visual aesthetic qualities alongside a critical but curious perspective on AI as an increasing part of everyday life. The process was driven by their own experiences with AI and a general interest in video as a means of visual expression. The programme's obstacles from intervention one vanished. The hybrid assemblage of actors was still present but played the role of a product enhancer rather than a parallel solution or escape. They knew about hacking, specifically hacking in the sense of positive intervention. Involving artist talks and seeing how artists use and discuss AI and pattern recognition in relation to art eased the technological capacity building and capability to reflect on it. Furthermore, the entangled technology and art-making increased their comprehension of big data as a tool for art as well as a societal perspective and concern regarding the reciprocity of data for the use of data.

The period of about eight hours was a challenge considering the qualifications and the development project's goal of developing students' technological comprehension as well as enhancing their digital skills and their visual aesthetic productive skills. Likewise, it was a challenge for the art teacher educator to frame the educational course content while being in a learning position herself and exploring how to use digital technologies in art teaching with a new technology-comprehension focus. The content derived from computer science seemed to overtake the art-making process in intervention one. However, it appeared that the bridging of everyday experiences from video production and hacking and the new learning field of technology as material for art-making fostered the critical and reflective approach derived from the field of visual artistic cognition in the second intervention.

5. Conclusion

The transition away from the tool metaphor towards a technological comprehension approach involving programming, construction and computational thinking provided the visual arts curriculum new content and the opportunity to teach digital empowerment from a visual arts perspective. This approach was an unexpected paradigmatic shift for the students who possessed another conception their visual arts education rooted in technology adapted to analogue means and modes for production. The study demonstrated that when integrating elements from computer science with visual arts education, the levelling of two different paradigms is crucial. While the difficulties with operating the software app took over in the intervention and diminished the art-making perspective, the second intervention led to both new artistic insights as well as technological comprehension of the working of big data. The experience from the first intervention revealed the various material actors that were involved in the process, which provided insights regarding the functions of the hybrid assemblage perspective, which may inspire a wider perspective concerning how a digital learning environment should be equipped and the richness of learning modes students use. Finally, the study showed how the educator needed to develop reconceptualising skills by transforming programming into hacking activities and thereby facilitating another approach to technology comprehension. The study concluded that teacher education in visual arts holds potential for using computer science elements for renewing the curriculum and framework for artistic learning. However, the artistic entrance for both students and educators is crucial for effective integration.

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