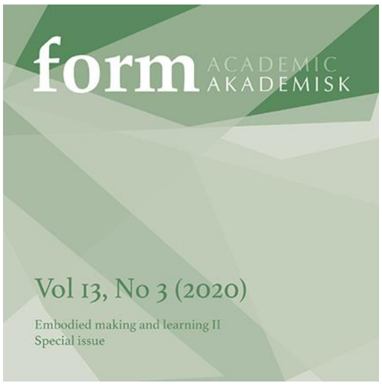

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Digital skills as ready-made or raw material?

ABSTRACT
In todays' digitalized society, there is a significant change in the material preconditions of learning, from specific and analogue to digital and virtual learning environments. Parallel to the massive digital investment in the Nordic education systems, a global movement called the "maker movement" has emerged. Through a study of curricula, learning theories, own practice, practical examples and the growing "maker movement", this article examines how this movement can contribute to a broader and more multi-faceted approach to digital competence in the arts and crafts. We question whether the education system and the education policy, to a greater extent, should rely on research-based knowledge on embodied- and material-based learning when developing arts and craft as a subject in primary school education.

Keywords:
Digital skills, craft, embodied- and material-based learning, maker movement, democracy.

INTRODUCTION

There is a significant change in the material preconditions of learning in todays' digitalized society. Where schools previously mainly revolved around concrete and analogue learning environments, they are now more digital and virtual. In the Nordic education system, a massive introduction of touch screens (iPad etc.) and corresponding learning technology has had a major impact on how digital skills in various subjects have become practiced. The EU's report on education and training in Europe shows that we know too little about how the change in learning resources affects learning and what form provides the best learning for students (EACEA European Commission, 2013). As the touch screen has been used in teaching for a while, more and more people are arguing for a more nuanced and multi-faceted approach to the form and the place it should have in teaching (Mangen & Balsvik, 2016; Mangen & Kuiken, 2014). They are critical to a school that is increasingly characterized by isolating pupils from the physical interaction with the world, by replacing it with virtual substitutes (Pirhonen & Rousi, 2018). A more solid research-based basis for the digital investment is being called for.

Within practical and aesthetic subjects, physical experience and physical interaction with objects and the surroundings have traditionally played a central role (Lowenfeld & Brittain, 1952; Montessori, 1964, 1965). In recent times, several theories of active, embodied learning and making with material and children have been proposed (Carlsen, 2015; Fredriksen, 2011; Gulliksen, 2017). However, also within this subject, the introduction of the touch screen changed teaching practices. New curricula for Norwegian schools show a renewal of interest in aesthetic subjects and their traditionally more practical and physical forms of work in school. The strategy for the curricula in primary school—joy of making, commitment, and urge to explore—point out how practical aesthetic subjects should play a greater role in a more creative and making-based form of education, both in their own subjects, but also in other subjects and in interdisciplinary themes (Kunnskapsdepartementet, 2020b). In parallel with the digital investment in schools, a movement called the maker movement has emerged in society. The movement has a positive and investigative attitude to digital development and new technology, but at the same time it focuses on materials, crafts, and people as important actors in making activity. This article will examine the maker movement approach to digital technology and learning. Together with the guidelines in the new curriculum, theory of technology and digital development, material, and embodied learning, as well as examples from teaching with students, the article examines how the maker movement can contribute to the arts and crafts (A&C) subject, for further development and an alternative approach to digital competence in the subject. The central question that has therefore been discussed is: what properties characterize the maker movements' approach to digital competence and how can these contribute to shaping the teaching practice in the A&C? First, we will discuss the place of digit aspects in teaching in the current and upcoming A&C-curricula, as well as the simultaneous growing maker movement. Furthermore, we will discuss this together with the theory about the body and the material's role in learning and digitization of society. Through an example of teaching, we want to show how characteristics from the maker movement can contribute to the development of a digital teaching environment more in line with the values and working methods elsewhere in the A&C subject. We also suggest some areas in need of further research.

Background

Digital skills, touch screen and making

Digital skills were introduced in 2006 as part of the general education in Norwegian schools, highlighted as one of the five basic skills, along with reading, writing, arithmetic, and oral skills. The basic skills are applicable in all subjects today, but the concretization and form of the skills have not been decided. Digital skills in, for example, the A&C subject have revolved around being able to use digital tools such as information search, image production, animation, and video and multimedia presentations, but how and with what tools has been to the schools and municipalities to decide. The school has met the guidelines in the curricula with a massive investment in touch screens, mainly in the form of iPads. Norway is now the country in Europe with most children with internet access through handheld technology (Letnes & Hardersen, 2016; Stats, 2019). It is unclear how many iPads are currently in circulation because the school authorities do not have an overview, but the daily manager of Rikt, the largest (and commercial) prosecutor in Norway that offers help and advice in digital school development, Erling Grønlund, can confirm that most schools in Norway now use the iPad for teaching (personally communication, 08.02.2018). On Rikt's website (Rikt AS, 2020), iPad use in the classroom is praised and described as fast, efficient and will optimize the student`s learning, workflow, motivation, progress and production. Rikt has itself been involved in the introduction of one iPad for every student in over 100 municipalities. This collective and one-sided form of digitalisation of Norwegian schools seems to be targeted and rooted, but it is difficult to find in what. Although the Nordic region is at the forefront of digital investment, the report on education and training in Europe 2020 is stating that we know too little about how the changes in learning resources affect learning. We do not know the consequences of the digital investment, nor which method of teaching provides the best learning for the student (EACEA European Commission, 2013).

As the touch screen has been used in teaching for a while, several people are advocating a more nuanced approach to the form and place it should have in teaching. The World Health Organization (WHO) is very clear in its recommendations. They say that time spent on screen, in too large quantities and at too early an age, is harmful. The time children spend in front of a screen should be reduced rather than increased (WHO, 2019). In Norway, the clearest voices have been linked to reading and writing education. They point to the unfortunate consequences of the absence of physical and bodily experiences with reading and writing when the iPad replaces book, paper and pencil (Mangen, 2016; Mangen & Balsvik, 2016). Mangen is concerned with how well one understands and is able to create meaning in what one reads. In the article *Lost in an iPad* (2014), she and her co-author Kuiken emphasize the importance of the sensorimotor prerequisites that printed media have. The book, with cover, leaf, binding and spine, offers material, bodily and sensory contact with the abstract text. Especially when children and young people read longer texts, the physical presence of the book is decisive for the reader's ability to orient themselves spatially, temporally and in terms of content. When you read on a screen, you lose coherence to a greater extent and are not as engaged cognitively and emotionally. Writing on the iPad also has a negative impact on learning, which differs from both handwriting and typing. Satu-Maarit Frangou writes in her recently completed PhD (2020) that students remember stories written on a computer keyboard better than those written on a touch screen. When children only use two fingers to write, their physical skills are limited. Mangen and Kuiken (2014) point out that no matter what we read, we also read the form of the technology we read it on, and the educational institutions should consider this when making decisions about digitizing of schools and subjects. Gulliksen and Søyland examined the picture book on screen as a picture book application and stated that "Physical interaction is key to a person's capacity to make sense of the world " (Søyland & Gulliksen, 2019, p. 2). Anchored in several studies, ranging from craft to learning science, they show how embodied experience and learning are the key to a person's ability to create meaning in the world (Sawyer, 2014; Søyland & Gulliksen, 2019).

Not only learn to use, but also create and develop digital technology

The curricula that have been in force in Norwegian schools until now were mainly formed in 2006, long before both the touch screen (iPad came in 2010) and virtual teaching were relevant. Competence goals in A&C primarily include (visual) communication and presentation, not development and technical understanding. Recently, the government came up with a new strategic plan for practical and aesthetic content in kindergarten, school and teacher education (Kunnskapsdepartementet, 2020a). Here there is an ambition to raise the competence and status of practical and aesthetic subjects. The strategy highlights subjects and the subject area's possibilities and intrinsic value and emphasizes that it is important to connect them to the digital investment in the school to develop the potential that lies in it. It emphasises that digital technology, creative activities and programming must be introduced to everyone in primary school. In the new curricula for the primary school, the superior part is the value basis that is to form the basis of the education. Section 1.4 is particularly relevant for aesthetic subjects. It is called the joy of making, commitment and the urge to explore (Kunnskapsdepartementet, 2020b). Here, the teacher is encouraged to facilitate the cultivation of different ways of creating through sensing and thinking. The student shall go through aesthetic forms of expression and practical activities to learn and develop. Making and creating are widely used terms in the new curriculum as it deals with concepts such as: the force of making, the joy of making, the power of maker, maker abilities and learning through making processes, etc.

Maker movement a creative movement

The maker movement started as an underground movement in the USA, initiated by programmers who sought to promote collaboration and open sharing culture through creative and physical work with digital technology (Blikstein, 2013; Hatch, 2013). The movement is a technology-based extension of the do it yourself (DIY) and do it together (DIT) culture and a continuation of fabrication laboratory (Fablab) and the 3D revolution of the pioneer Neil Gershenfield (Fabfoundation, 2019). The movement is also based on science, technology, engineering, (arts) and math (STE(A)M-) pedagogies with focus on the practicing skills students are thought to be needing in future working life, such as working with real problems taken from the real world. The movement is a rebellion against the digital development where the user plays the role of the consumer of digital solutions or reduces digital skills for computerized knowledge. They want to move away from instructionalism in school and practical subjects in insulated silos, instead they want the work to be exploratory, interdisciplinary and in close contact with practice. The maker movement has clear similarities with the Arts and Crafts movement that arose at the end of the 19th century, in the wake of the industrial revolution. Well into what is being referred to as a digital revolution, the movement shows the same focus and care for the craft, working with materials in a workshop community. Like the relationship of A&C to the industrial development of society, the maker movement is also not a polarized and reactionary protest, but instead wishes to be an active participant and a clear voice when the premises for the digital development are to be discussed and decided. The research field that follows the maker movement shows that it may be a good idea to look into the movement to find solutions in work with programming, development, maker activities, digital technology and technical understanding (and sustainability, citizenship, democracy, etc.) (Dixon & Martin, 2017; Fasso & Knight, 2019; Gutwill et al., 2015; Hsu et al., 2017; Sheridan et al., 2014).

However, even though the movement is gaining increasing attention and more scholars are on their way to the maker arena, the movement is both understood and practiced in slightly different ways and is not always in line with the intention of the maker ideology. In a recent literature review from a Finnish research team, it appears that there is great variation in how different actors shape the learners' experiences and, in that context, how available resources such as tools, materials and examples affect activity in different makerspaces (Iivari et al., 2017). Although the maker movement has been praised worldwide, with a foothold both in informal learning situations, school and in academia, with subsequent publications, there is a lack of good vocabulary to talk about making and children. A previous study highlights the need for deeper analysis of the field (Iivari et al., 2017). The educational institutions have largely invested in equipment, but not in competence and development related to how to work digitally on the A&C subject's premise. A literature review shows that research in several countries has followed the maker movement for several years already (Iivari et al., 2017). Although Norway is in the forefront with the digitization of education (and the introduction of the iPad), and the maker movement is about to take root also in this country, more research is needed both related to the movement and to the consequences of the form of digitalisation of education till now (Mangen & Kuiken, 2014).

This article seeks to contribute knowledge and solutions precisely on how to work with digital competence in the A&C subject, in line with the subject's own premises, currents in the maker movement and the guidelines in the new Norwegian curriculums 2020. By examining what characterizes the maker movement`s approach to digital competence, we will seek to highlight and discuss what can be good core elements to build on. The article first deals with a theory and literature review, where the characteristics are made visible, based on what is already written on the movement. Further, we take with us these characteristics into a teaching program and test them there. In this way, we will investigate how they can contribute to building a bridge between ideology and practice in A&C subjects and based on this, seek to contribute to a renewed form of digital teaching and learning.

AUTOETHNOGRAPHIC METHOD

In the investigation of the curriculum guide, we will use autoethnographic methods where our own experience from teaching constitutes the main subject of the investigation. We also want to incorporate the students as active participants in research where they are given the authority and voice to provide their own contributions (Ellis & Bochner, 2000). In the autoethnographic method, there is a point that readers are also participants and receive the opportunity to "…feel the moral dilemmas, think with our story instead of about it, join actively in the decision points… " (Ellis & Bochner, 2000, p. 735). One should seek to give a wide and rich presentation of the field, write both engaging and evocative, and thus invite readers to a vicarious experience of the events that are told. Although our lives are special, they are also typical and generalizable through the limited number of cultures and institutions we participate in. The stories we tell along are continuously tested by readers based on whether they be-

lieve in what is being told and can feel and experience themselves or others they know in the stories. In this context, it is also important that the authors present their attitudes and pre-understandings so that the reader understands where they stand and can follow their conclusions (Ellis & Bochner, 2000).
The writers of this study have both been involved in planning the framework of the project and the analysis of collected material afterwards, whereas Høibo is mainly responsible for the practical implementation and fieldwork with the students. We teach at Department of Visual and Performing Arts Education, with somewhat different approaches to the field, but we still have a common interest in the development of technology and its role in education. Lerpold is an art historian and philosopher and teaches culture and aesthetic theory. Høibo started teaching the year the iPad was launched and was early given responsibility for digital teaching in the A&C subject. In the beginning, she saw many learning possibilities in the touch screen, how it for example could physically be brought into workshops and in greater extend integrated into maker activities, than ordinary ICT teaching in labs. After a while, limitations also came to light, and in that context, the maker movement has inspired new ways of think around and work with technology in A&C subjects.

The case investigated involved a student group (23 students) at The University of Southeast Norway (USN)'s Bachelor program Visual Arts and Design (VKD). These were second year students who have already studied the basic within drawing, painting, wood, metal and ceramics, film, video as well as art and craft history. The subject of this course is based on makerspace, it is 10 a credits course and lasts for 6 weeks. The material that is analysed and referred to in this study is the students' exhibited solutions and processes with trials (prototypes, drawings, and modelled sketches), as well as project reports with photos, drawings, and text (23 pcs.). Together with Ingrid's fieldnotes from the contact teaching with the students and photos from the period, this material constitutes the empirics of the project. The material has been reviewed and sorted under the three characteristics from the maker movement that emerged in the literature review. Here, we focus on examples and extracts that confirm, refute, add, or expand the three main characteristics from the literature. The examples are finally discussed in the light of the theoretical framework of the article. The students quoted and depicted in the article have approved the use of images and text material.

The framework for the students in this project differs somewhat from teaching A&C subjects in primary school, both in form of the experience the participants bring with them, age, time they have available, materials and access to resources. However, these frameworks provide some unique opportunities to work thoroughly, deeply and for a long time with the issues we raise in the article. Using the students' experiences and competencies, we can look at their contributions and themselves as competent participants and co-researchers. The process, their trials and solutions can therefore be good guides that the A&C subject in school can benefit from.

THEORETICAL FRAMEWORK

Embodied experience and learning, the possibility of physical contact with the world and the connection between human and machine are relevant areas discussed in this article. We have mentioned that bridging is needed between digital technologies and practical-aesthetic subjects; it can include different inputs for example dialog with the field of practice, art history, psychoanalysis and philosophy of technology. An example of the last is the French philosopher Bernard Stiegler (Stiegler, 2016). He is interested in how technology that was meant to release and relieve us, instead gradually is turning us into slaves. The automation of society is a logical step in the development, and developments in technology have, from the beginning, influenced and changed people, but the material anchoring the culture has also followed closely. Now, with digitalisation, there is a global and comprehensive acceleration, which is constantly escalating, and humans have trouble connecting technology with a parallel civilized digital culture (Stiegler, 2016). Hartmund Rosa and colleague (Rosa & Wagner, 2019) also writes about the role of humans in the digital society. He embraces the terms resonance (reverberation) and degrowth and want us to slower the rootless moving forward, the constant acceleration. Instead, man should be given the opportunity to have one bodily anchored relation to the world. A common public space where man, slow and tolerable, can be present and spend time in creative processes. Instead of growth, one should slow down the pace and consumption, so that the future becomes sustainable and one avoids desert landscapes both in nature and in man (Rosa & Wagner, 2019). Byung-Chul Han writes about how the real is broken down in the imaginary world (Han, 2017). The hands become superfluous, and the digital does not offer the material resistance that one otherwise has to overcome with work (Han, 2017). Material resistance (the real) is rejected when digital communication opens up for an increasingly body- and faceless space. In this sense, it gives rise to a narcissistic space, a digital reflection, where the other does not exist as another, nor as resistance and distance. Han writes that due to the efficiency and well-being of digital communication we are increasingly trying to avoid direct contact with real people and the real at all (Han, 2017).

Richard Sennett is also concerned about this in his book The Craftsman (Sennett, 2008). Here, he examines the roles of human, craft and material when building and creating culture. He maintains that precisely the resistance in the material, what the material gives back to the one who works with it, is what builds and develops the craftsman (Sennett, 2008). Sennett writes that the busy times we live in is taking from us an innate and necessary rhythm in the work. Doing a job thoroughly will take the time required, and here must be room for thoughts and feelings to be involved in the process. The pressure to deliver has reduced the ability for reflection. In the fragmented life we live, where one switches, surfs and constantly changes focus, qualities such as depth, memory, concentration and repetition in working with a craft are rare. He writes that where there is no room for reflection and a continuous commitment, also the quality will fail. Sennett sees the full satisfaction of physical production as a necessary part of being human. We need craftsmanship as a way to stay anchored in a material environment, and as a counterweight to values that overestimates the mental aptitude (Sennett, 2008). These thoughts can be traced back to the 18th century, where manual activity was equated with mental labor, as well as the Arts and Crafts-movement at the end of the 19th century which raised the value of well-executed craftsmanship. However, good craftsmanship can occur unexpectedly as well; as in Linux workshops in the 1990s, as Sennett writes (Sennett, 2008), a group of programmers was initiated by idealists and enthusiasts, similar to the starting point for the maker movement.

Minna Lakkala early developed a framework for studying various aspects of learning culture in Makerspace, and this has been further refined and modified through use in several research projects (Davies et al., 2020; Lakkala et al., 2010; Lakkala et al., 2008). The framework regroups the central area in the maker movement and provides a framework to study the pedagogical infrastructure that supports and builds up under maker-centred practice and work. The main pillars of the framework are 1) epistemological infrastructure (pedagogical principle for learning and teaching), 2) social infrastructure (the social and physical arrangements for organizing collaboration and interaction for students), 3) material-technical infrastructure (disposition and advice, function and ability / adaptability to tools and technologies; organization of technical advice or guidance), 4. cognitive infrastructure (designing tasks and support structures, models that promote students' competence to work in an intended way) (Davies et al., 2020).

These main pillars we bring with us, and they form the basis for the organization and shaping of the teaching program at USN, but it was also used to study and understand what happened and unfolded in the period.

Maker movement and learning

Seymour Papert (1993) was one of the first to highlight the importance of physical and practical learning in technology education. He is called the founder of the maker movement, and the ideologies underlying the movement are close to his early ideas. Instead of using technology to optimize teaching and learning, Papert is concerned that one should look at it as a liberation tool that gives the most powerful building materials in the hands of children. For children to be active and involved in their present and future, they should rather be given an opportunity to manipulate the medium to their own advantage and deal with unintentional and unexpected problems when they occur, than to consume and fill in pre-designed templates. Papert had early and visionary predictions about how the computer would totally change school as we know it (1993), but these did not happen as he thought they would. Critical voices claim that it is not about the technology itself, but rather that one has not been able to exploit the learning potential and possibilities offered by technology. The maker movement has continued Papert's thoughts and gave them renewed relevance through activity and enthusiasm. However, even if many can agree on the ideologies behind them, several have subsequently been critical of whether they fully endure in the practical activities and day-to-day work. Is the movement as sustainable as it claims to be (Kohtala, 2017), or is the sharing culture as present as it should be (Johns & Hall, 2020). Selena Nemorin has studied students and themself in partner teaching and is critical of what one really learns through forming on 3D printers. She thinks making can serve as a democratization of the classroom where one builds knowledge together, but one must, in no way, accept this as a solution to reforming and renewing the school alone. Instead, one should look at contributions from the maker movement as methods for teaching and learning with the same pitfalls and obstacles that other digital technologies have brought with it (Nemorin, 2016).

In the eagerness to introduce maker activities, some scholars resort to easy solutions by purchasing starter kits and similar, with ready-designed assignments for each student to perform a task in the same way. Thus, one goes away from central ideals in the maker movement, such as having open tasks initiated by the user himself, or rig for work in raw materials and learning through trial and failing. Research shows that lack of knowledge can lead teachers to choose passivating learning resources, rather than what the original intention is in the maker movement, and that learning thus acquires a mechanical, instrumental character (Fasso & Knight, 2019). The same gap between ideology and practice can be found in the practised A&C – subject and the way digital skills is being thought. Educators surrender their ideals associated with active, embodied learning and physical creation with material when it comes to working with technology and practicing digital skills (Pirhonen & Rousi, 2018). We must try to develop digital teaching in the A&C subjects more in line with the ideals and values which the subject is built on. Characteristics from the maker movement that can help shape digital skills in line with the A&C subject that we want to highlight are the following:

1. Human, material and physical learning: the movement is concerned with human having physical interaction with the material, the technology, to be anchored in the world, where man is a key player in digitalisation. Through experience with the physical world, and the bodily approach to abstract concepts, meaning creation and conceptual understanding are developed (Gutwill et al., 2015). The craft element and the interaction with the materials helps us understand what lies behind technological solutions (Gutwill et al., 2015). The Makerspace, with its rich diversity of tools and materials - both high-tech and low-tech, traditional, digital, and physical, offers a multimateriality that can expand traditional arts and crafts education as well as digital and technological learning (Seitamaa-Hakkarainen et al., 2013).

2. Process over perfection: In extension of the point above, the focus on process is also greater than product in one makerspace. Human, the activity and learning that takes place in the individual and in the community, it is the main thing and the very value of a makerspace. Through making, trying and failing and trying again, the learning is encapsulated and the production of learning is just as important as mastering a limited and predetermined set of skills (Sheridan et al., 2014).

3. Sharing culture, open and democratic community: The makerspace connects disciplines and professional fields that are traditionally separated, such as sound and technology, textiles and coding, and electronics and design, and work like this is interdisciplinary both in approach and production (Sheridan et al., 2014). This mix of traditional and newer digital skills facilitates a learning environment with numerous entrances and possible ways to attend. The social community/ scaffolding (Gutwill et al., 2015) is an important mainstay/pillar in a makerspace. Here, the maker movement marks a distance from societal tendencies such as individualization and isolation and instead promises openness and

sharing as important values. Knowledge is processed though tools that participants can use and build on. What has already been developed can be further developed by others, in this way one develops both the project and the knowledge in the individual.

MAKERSPACE IN THE CONTEXT OF ARTS AND CRAFTS EDUCATION

Based on the three main areas from the movement mentioned above, we designed a course. We will next present experiences from the implementation of the course and then discuss these in the light of the theory presented above. The pedagogical framework original design from Minna Lakkala`s (2008) forms the framework for the course.

1. *Pedagogical principle:* the assignment was open with room for the students to form their own goals and directions, but with sustainability as a theme, chosen on the basis of one of the core values in the maker movement. This is also a focus area for USN and, in addition, an area in which many young people are involved. Based on the UN's sustainability goals 13, 14 and 15, with a focus on climate and life on land and in water, the students were to work out a comment on our times major climate challenge. The task was thus not linked to a clear goal, nor a specific product, but open in form, content, size, material, technique, and direction. The first week was used for collecting material and knowledge and joint brainstorming that provided the basis for further work. The process and documentation of this were important. It was just as important to experience and to document failures, as well as the successful solutions.

2. *Social infrastructure:* the teaching took place in USN's DigTekLab, a newly opened makerspace with a large and open common area where there was room for everyone to work at the same time, preferably with different things and in different parts of the process. It was also possible for the students to share acquired knowledge and skills with one another, both about what they brought into the project from before and what they acquired from the project. Teachers and staff in the makerspace were available and responsive to what skills, teaching and help students needed along the way, and they were learning and exploring, together with the students. It was up to the students to decide if they wanted to do the project in groups or individually.

3. *Material and technical infrastructure:* the students had a rich supply of materials and tools, both in the makerspace and through students' access to the university's workshops and materials. USN Campus Notodden has well-equipped workshops for wood, metal, ceramics, textiles and different surface treatment materials. DigTekLab gave students access to laser cutters, 3D printers, vinyl cutters, soldering equipment, programming equipment such as adafruit, micro: bit and related extended equipment, electrical components such as LED lights, motors, small servos, sensors, and various conductive material. The students were in addition encouraged to collect and bring their own material, garbage and surplus material, damaged electronics and other things they would get rid of anyway.

4. *Support structures:* Several stop points and courses were planned when they were needed in relevant topics. Stop points led up to sharing, presentation, discussion, feedback and joint development of ideas and frameworks for the assignment. Among the courses we anticipated would be needed were the use of the makerspace equipment such as laser cutters, 3D printers, programming, mechanics and electronics. We invited several of the members of the “Norway's makers” association to provide introductions and inspirational lectures about one's own and others' maker work.

IDEAS AND COMMON COLLECTION OF MATERIALS AND KNOWLEDGE

We started the course by reflecting together on what form and direction the work would have. The students spent the first week gathering information and material. This material was shared together, and we got ideas written and drawn on boards where everyone could see them. In other words, the ideas and knowledge were jointly owned and could be picked and used by the individual or groups as desired (Figure 1). For some, it was probably unfamiliar to share their own ideas so freely, but the commitment was increasing, and the students built on each other's work, as it gradually became visible. Several of the final results from the period had their origin in the same idea but took different directions in the work process. The overall content of the collections gradually moved in the direction of a zoological museum of the future with creatures of the future with various adapted properties or inflicted damage/changes caused by climate change. The task was developed jointly, but after the content had been decided, each took hold of their essence and worked on this. Subsequently, the goal for the student group was to create a zoological museum of the future, with exhibited animals that had either adapted to the climate challenges or were damaged/changed by them.

Shape the creature

Based on the direction of the theme and content, we went further in designing the creatures. There were several students who wanted input on modelling and shaping of the figures. Therefore, we arranged a *fabulous animal factory* with the illustrator and the fabled animal maker Line Renslebråten. She had an assignment where the students got a lump of clay that first had to be shaped like an egg, and then the student should let it "hatch" in their hand by shaping and modelling the clay. What then was made visible was a future animals/being. Furthermore, a presentation of the creature was to be made where the student found out what it was, were it lived, what it ate and what it would look like when it grew up.

Materials, mechanics and programming

From here, the work with form and properties began. What came into view in the hand would have character, feelings, motions and movements. The students were encouraged to use tools and materials from the lab, and we had set up courses for the use of these as well as programming and mechanics. The students first worked manually with the mechanics, using simple model sketches with steel wires, cardboards and duct tapes. If, for example, the beak should chop, or the eyes should blink or shine, the students had to examine what angles, gears, materials and joints were needed to achieve the desired effect. In this part of the work, some were dismantling mechanical stuffed animals to examin how the mechanics were put together and worked to move a tail or a foot. Other parts of the animals could also be picked from and used in new creatures. There were no limitations in relation to the material, shape or size in the assignment. The students worked independently with the figures using plastic, steel wire, cardboard, clay, and fabric. Some students had a surplus of fake fur in various variants from an earlier project, and this material came to dominate many of the finished solutions.

One student took it upon himself to collect all the rubbish on the road between the university and the dormitory. She sorted this out and built a plastic dog (Image 2), with references to the plastic quail, which could chew through rubbish if you fed it. The 3D printers were always in use, especially in the latter part of the period. There sometimes became a queue and the students had to wait for their turn. Some chose to print large parts of the figure, most used 3D printers for smaller parts in the form of gears, joints, eyes and extending arms for the servo, etc. One student made a lot of work to give shape to a tail fin. Many prints were tried by adjusting the resolution on the file, input, speed, and position. The goal was to get the grooves in the print to go the right way. Another student worked on getting the tail to swing just right. Foam rubber, cardboard and scrap steel were tested, but it was as she came up with the idea to connect a lot of 3D-printed parts together, that she was satisfied with the movement. Furthermore, the students worked with block programming which they entered on minicomputers, mainly open source solutions such as micro:bit and adafruit. We showed examples of how the students could work with movement, animation with servos, light and sound or how they could make the creatures react to their surroundings through sensors or triggering switches and buttons. The future being gradually gained life and movement. Some could shoot laser beams and growl, others lit up in different colours, winked their eyes or flew with flapping wings.

FIGURE 1. Collaborative ideation process, Makerspace 2019.

FIGURE 2. Work with luminous laser eyes, teddy bear transformed into a plastic dog, disassembly of electronic toys, 3D printing of fish tails, programming of movement in head and tail.

Two examples: one small and one large

Among several good projects, we could have chosen to highlight more, but out of consideration for the allotted space in the article, we have made a selection based on the largest and the smallest solution. These two are nice contrasts in several ways and cover the breadth of what unfolded during the period well.

The one who got started first was the student who wanted to make a polar bear of natural size (Picture 3). The polar bear plays an important role in environmental issues, and the student wanted to give the creature qualities that could show how climate change affects here. According to the student, the expression should be cuddly and sweet and look beautiful on the outside, but the fur should signal how the polar bear actually felt in the form of a changed colour. If you came too close, the bear became red, and if you were too far away, it turned in to blue. To achieve this, the student had several solutions, for example a fabric inserted with colour that changes with temperature, for example via a sensor of temperature at the North Pole. He tried different ways of getting the effect he was looking for and the final solution was to insert the faux fur with small LED lights in the colours red and blue and connect a live wire. To make this work, the student had to test how many lights the battery could support. After a while, it turned out that it was the quality of the bulbs that had the most to say for the light quality. The student also had to learn soldering, as it was not included as a course in the study. He turned to the maker network on-line, got good help there and could later share newly acquired knowledge with his fellow students. He soldered together an entire network of lights and used micro:bits and sensors to control the function. The student writes in his log that he has learned an incredible amount, especially about soldering and programming "also that it is possible to fix things you have around you with a minimum of equipment and imagination". He hopes that the bear opens up for dialogue with the public about global warming.

FIGURE 3. A polar bear comes into being, with networks of light under its fake fur.

The smallest solution was a small dragonfly with spurs and tentacles on the wings (Picture 4) to catch the excess of carbon dioxide. The body itself was printed in PLA on a 3D printer, and the wings were made of cardboard that was cut on the laser cutter. The student was concerned with getting the right structure and engraving in both materials and tried several variants and trials before she was satisfied. In the work on the laser cutter, she wanted to engrave the correct translucency in the wings, without them becoming too fragile. To make the wings vibrate, she used two small vibrators and drilled holes for the cord just below the wing attachment. Then, she soldered together and mounted it all to a battery holder with a switch that she printed on the laser cutter. She writes that she wanted to comment on the UN's climate goal 15 by making an eye-opener that was adapted to a future large CO2 emission. The comment becomes even clearer when the beautiful but fragile creature conveys the negative environmental development.

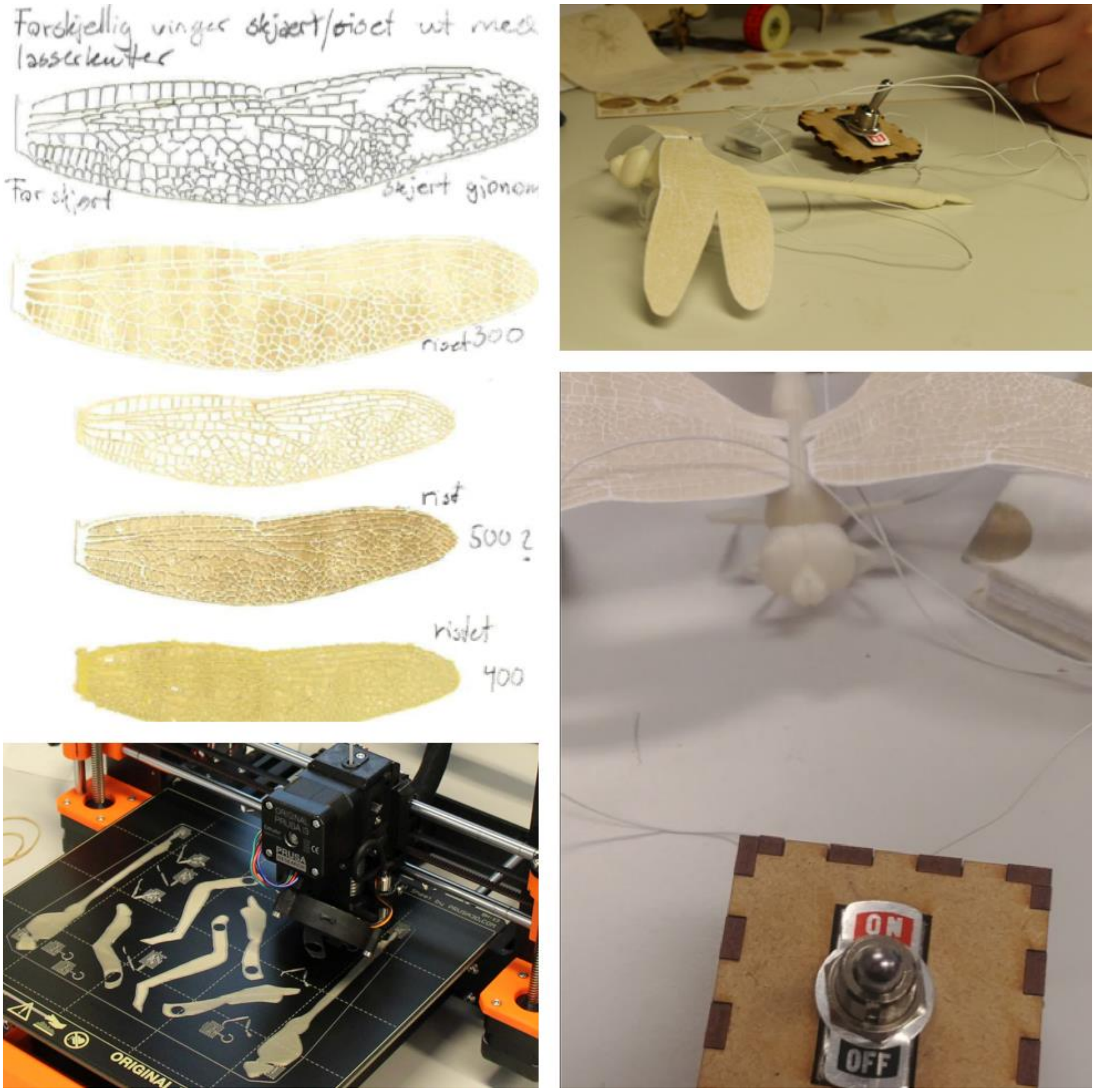

FIGURE 4. The smallest solution, a dragonfly with vibrating wings.

A NEW DIRECTION FOR DIGITAL COMPETENCE IN THE ARTS AND CRAFTS SUBJECT?

Through the work with students and maker-centred teaching, some key aspects emerged that we will present and discuss under the headings from the main maker areas.

Human, material and bodily learning

The students had to brace themself on both known and unknown materials and tools, and it was clear that they could use experiences from previous projects as they faced new ones in this. Even though they had a rich selection of newer materials and tools available in DigTekLab, they mostly used materials they already were familiar with such as chicken wire, fabric, cardboard and duct tape. As the ideas took physical form, the students began exploring the possibilities for specific movements and properties also in the newer materials and tools such as the 3D printer and the laser cutter. The students programmed movements such as making a head turn and eyelids blink. In this way, they worked with both digital and analogue technology. On the screen, the students programmed the code for the movement, and then, they brought the movement to life, through micro:bits etc. in the figure and thus made the movement analogue. The movement did not always go as planned. The wings may flap down instead of up and the head may spin in circles or not at all.

The students encountered such experiences on several occasions, and then, they had to work on the codes, the material, or the mechanics to find what was the cause. This movement, in and out of the digital and material, gave the students a bodily and physical experience with concepts and functions that can otherwise be experienced as abstract if they stay inside the screen, as Gutwill et al. stated (2015). The same applied to the work with 3D printing of digital drawings. Here, the students worked with digital drawing which materialized in the print. The students gained experience in giving shape to melting PLA (also known as Polylactic acid, a thermoplastic polyester derived from renewable, organic sources such as corn starch or sugar cane) and were teamed up and built models. Through experimentation and many trials with different file resolutions, feed, speeds, and location, they got familiar with the new tools and materials that gave them resistance (Sennett, 2009).

The numerous repetitions, through repeated trials, gave a necessary rhythm to the work that the busy and efficient times we live in rob from us (Sennett, 2009; Han, 2014). The students got to experience the limitations of servos that did not endure the weight of the cardboard. They came across advanced movements that required deepening in logical thinking; for example, how to achieve soft and elegant sweeps with a tail? How to assemble the gear and strut so that the head spins the right way? How to avoid short circuits when working with living material? Is the problem in the current-carrying sewing thread, in the micro:bit or in the code or the material? The knowledge they acquired in these processes required patience, time, and courage, but with this came room for depth, concentration, and reflection. The framework in the project was set up so that the students could acquire and develop knowledge gradually, layer by layer, with room for reflection and in-depth learning as envisioned in the Utdanningsdirektoratet, (2019). The experiences were embodied and anchored in the physical and material, thereby making learning robust (Sheridan, 2014; Sennett 2009). Through work with both digital and analogue tools and materials, knowledge was anchored in material experience (Sennett, 2009; Han, 2014).

Process over perfection

The work process of the students was given great weight during the period. It was an educational goal that the process should start from their own motives and personal commitment, something that would trigger the students to be emotionally invested (Gutwill et al., 2015). This is how learning and knowledge, in the community and in each individual, would be built and driven by the students themselves (Gutwil et., al. 2015). The theme for the task was set, but the students chose what and how they wanted to comment on the climate challenge. Most of the student's focus were based on areas they were concerned with, and that the students were, in general, impressively knowledgeable on. But even though they could choose some aspects, the task was still not completely free and open to the individual. The pedagogical framework provided some guidance such as a selected workspace, theme, courses, and stop-point, but the most dominant was still the leading that arose from the student community. Some individuals' voices said more than others, some were heard, and others followed. Some were more engaged and active in the work, got started early and worked hard, while others had to catch up along the way. It was a challenge to get everyone engaged equally, so that each individual had a place and role where they could experience good and educational processes and feel that the task as meaningful to them. When the traditional hierarchy between teacher as expert and the student as 'noob' was abolished, at the same time as the goal was unknown and was something one had to work towards together (Dixon & Martin, 2017), it was challenging to find a good and balanced form between leading/ instruction and facilitation for the students. How should one behave as a teacher when the process and the path students apparently choose, do not lead to learning? Stiina Sinervo (2021) has investigated collaboration in design processes and highlights that such open assignments in no way must be understood as the absence of teacher involvement. These processes rather need close follow-up from the teacher to succeed. The teacher must not reject or refine the students' design ideas, even if they are poor; instead, one should give them choices that they can ponder by challenging them to examine the pros and cons of different design choices. The teacher's role should be filled with creating preconditions for the student to have, or have access to, the skills they will need to perform the work.

It is also important that time is given to the division of labour, organizational processes, and room for personal responsibility early in the period (Sinervo et al., 2020).

Through observations during the period and reading the students' project reports, it becomes clear that many have had instructive processes, but for some, it is more difficult to confirm. It is, in other words, not automatically that open tasks will generate personal commitment and lead to valuable processes where learning is encapsulated in action (Sheridan et al., 2014). With freedom comes responsibility, and some students should have been given more support to take that responsibility. The period should also have been facilitated for organization and division of labour early on, with teacher guidance close by, that could catch those who were not directly hooked. It is an important point in the maker movement that learning takes place through trial and failing (Sheridan et al., 2014), but then it is important that one fails in the right direction so that it leads to solutions rather than accidents. In this context, the teacher's role is also important, that the teacher is available, observant, and close so that the student get started again and can continue with the work. It is also important that teachers give value to the process of failed trials and demonstrate to the student the qualities of these and the learning that has been acquired.

Sharing culture, open and democratic community

This open and collaborative approach to solving the task stands in strong contrast to the individual performance ideology that more often takes place in the formal learning arenas (Dixon and Martin, 2017). For those who managed to take advantage of the opportunity, there was a lot of learning to be gained both through each individual process and in the community. This was especially true for those who were also open to others' input on their own work, engaged in others' problems and willingly shared their own ideas and knowledge (Gutwill et al., 2015). The study shows that to move from individual focus to diversity and collective processes, where different competencies meet, also means that one loses control over the result. In this, there is a risk of whether one (or all) will achieve goals and results, but at the same time, it opens for a diversity of approaches and unexpected solutions. There were several new discoveries and trials in unknown terrain and unexpected challenges one had to overcome. For example, there was no one who had soldered pipes together in advance, but almost every student needed this skill along the way.

The student who was the first to learn how, lead the learning way for the others. He turned to the maker community online and gained access to both training videos, instructions, and direct answers from individuals in the network. Through trial and failing, together we found soldering techniques, materials, and craftsmanship. This new knowledge became material that the whole student group gained access to. In this way individual problems come to be common challenges, and the knowledge that was brought in from the maker network was a common tool that all students could use and build on (Gutwill et al., 2015). Throughout the project period, this dynamic was present, from the students' individual ideas and processes to the community and the group's project. Together they discussed and shared experiences with students, building knowledge on each other's work. Everyone could contribute and influence the development. As in Sennett (2009)'s description of The Craftsmen's guild, the students got to study digital technology, mechanics, and programming and through working with this they both built each other's skills and projects good. It was a common knowledge development where learning in process was the important thing, not the solution (Sheridan et al., 2014).

The new curriculum is seeking to facilitate different ways of creating and making and is highlighting the use of aesthetic forms of expression and practical activities, to give the student the opportunity to learn and develop (Utdanningsdirektoratet, 2020). This task gave room for the creation of both a huge polar bear and a tiny little dragonfly, that were very different and unexpected both in terms of material choice, shape, size, and project. Such processes, where the goal is not predefined, allow for democratic decisions and participation. The point is not to reach a specific solution; the student is actively involved in their own learning path that they set by themself and that becomes the premises for learning, for themselves and for the student community.

The students also gained insight into, and experience with, technology that is otherwise hidden behind seamless user interfaces or in fur and plastic. They disassembled electronic stuffed animals and studied the mechanics behind the solution. Instead of working with digital technology through readymade solutions that developers have designed for them, the students programmed movements and functions themselves. Parts from damaged electronics got new life in the students' self-composed creatures.

The students do not become trained programmers through such a project period, but they acquire skills that enable them to manipulate the medium to their advantage, in line with Papert's (1980) theories of physical and practical learning about and with technology. This way of working and the insights they acquire by opening up and investigating a solution that is meant to be consumed in the closed and finished form, gives students power. They are no longer bound to adapt to what the manufacturers have planned for use. It is a democratization of technology that makes students active manufacturers instead of consumers of ready-made solutions.

Basic skills

A part of the A&C subjects has been about basic skills one would need in everyday life, like to stuff a sock and carving a stool. Some of what we consume most today is electronics and technology, but here, most people are helpless if something should be destroyed and in need of repairing. When you gain insights into some of the mystery behind a seamless and intuitive user interface, you will probably be able to fix it yourself to a greater extent (instead of buying a new one) or at least understand enough to know what you as a consumer can expect. The students who opened up and examined destroyed electronic stuffed animals and put them together in new ways do not have to accept that the product is rubbish when parts stop working. This insight gives power to consumers and puts pressure on the digital suppliers.

Through the students' work with digital and analogue tools and material, the knowledge was anchored in a material reality, and it became tangible and manageable. In the assignments, there was room for the students' own involvement, and they were allowed to contribute and shape learning from a personal commitment. Along the way, the students encountered real problems that require knowledge and skills that the student must acquire to solve them. In this way, the students' learning is anchored in personal commitment and problems that are relevant and meaningful for the students where they are in their own learning processes. This way of learning stands in strong contrast to the digitization of education that Rikt argues for; it is not at all efficient, fast, or seamless as Rikt describes learning through the iPad (Rikt AS, 2020). The process requires patience, time, and effort, but if we really want to give the next generation the opportunity to participate in their present and future, we must equip them with the basic skills that give them power, knowledge and the ability to influence digital solutions. As Sennett puts it: "... we can reach a more humane material life, if we only understand the creation of things better" (Sennett, 2009, p. 18).

DIGITAL COMPETENCE AT THE PREMISES OF ARTS AND CRAFTS

In the A&C subject there is an openness and interest in integrating the digital in teaching, but the form and content up until now have been unnecessarily limited by the tool that has been introduced and used. The touch screen has shaped teaching, but decisions related to content and form in subjects should not be left to profiteers and the latest technological innovations. We shall not stop or reverse the digital development, but build the material anchored culture that follows (Stiegler, 2016), and this must be done in line with the subject, through what we know about physical learning, material and physically anchored knowledge. The maker movement offers physical and practical learning about and with technology. Instead of using technology as a tool to optimize and streamline teaching and learning, one learns to handle and create with technology. In the same way as we otherwise treat tools and materials in the A&C subject, the movement raises the possibility of working with digital technology as raw material, without pre-defined solutions.

Now, the new curriculum guide is about to take effect, with clear elements of the maker movement in it. There are many schools that have plans for, or are in the process of, creating a makerspace and is incorporating the movements ideas into teaching. Although this article highlights characteristics of the movement that are worth considering in the A&C subject, it also shows some pitfalls that one must try to avoid. When introducing contributions from the maker movement in the school, we must learn from the experiences of previous introductions of digital technologies and ensure that the maker movement does not become a loose solution to renewing the school alone (Nemorin, 2016). This time, the introduction must be firmly rooted in the subject and be followed by the research. Furthermore, it is important that the professional and research-based knowledge reaches the schools and pupils.

The guides in the new curricula, a growing maker movement and a focus on programming and aesthetic subjects in school provide opportunities to use the A&C subject and the maker movement's properties to give new content to digital skills. Here, the A&C subject can become a guide towards a co-creative and actively participating form of the digital skills that are taught. Together we must come up with good solutions on how children and young people can be nurtured to become active and participating citizens of society, who are present in their lives and are given opportunities to influence the development of the future in which they will live.

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