Digital Literacy and Course Design

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Abstract: This paper presents a course planning model for lower and upper secondary schools in the fields of digital literacy and computational thinking. The examples in the paper are based on a Danish regional project entitled “crossingIT,” in which about 35 unique courses were developed and conducted by local educators. Duration of the courses ranged from approximately two hours to four a week for fifteen weeks. The model highlights four perspectives in course planning: (1) a traditional planning perspective, with a focus on learning objectives, learning activities, practical organisation, evaluations, etc; (2) methods for teaching digital production such as iterative design cycles, pair programming pedagogy and video tutorials as well as textbooks; (3) the field of digital literacy including, for example, computational thinking skills, ethics, critical thinking and societal perspectives; and (4) Environment, including local company participation, career learning and cross-school teaching. The model can be used for both planning and analysing courses in the fields of digital literacy and computational thinking. The article offers specific examples of teaching methods and specific cases from practice. Teaching in this field does not have a long tradition in Denmark. The model provides specific advice for well-rounded didactic planning in the fields of computational thinking and digital literacy.

Keywords: digital literacy, computational thinking, teaching, learning, course design and didactics, coding and programming

1. Introduction

What is important for educators and managers to consider when teaching programming, digital design and digital literacy in secondary education? Are there didactic methods specifically related to digital design and digital production? This article presents a model for planning and evaluating teaching in programming, digital design and digital literacy.

The model was developed for secondary education in Denmark in collaboration with teachers. The teachers were part of the ROBOlearning project (2018-2020)[1] which included four upper secondary schools, with most students ranging from 16 – 19 years of age, and five primary and lower secondary schools, focusing on students ranging from 13 – 15 years of age. The upper secondary schools encompassed general Upper Secondary School, Technical and Commercial Upper Secondary School and Vocational Education and Training[2]. In addition, the model was used to evaluate 18 of 35 courses in digital production and digital literacy in the “crossingIT” project (2017-2019).[3]

The learning perspective in this article is based on experiential, collaborative and participatory learning processes as described by Kolb (1984), Wenger (1998), Papert (1993), Schön (2001), Rusk et al (2008), Resnick et al (2009) and Majgaard (2015), among others. Learning often takes place when the students actively participate and experience new subject matter. These experiences need to be explicitly reflected upon in the community of practice in the classroom.

The new didactic model “ROBOdidaktik” (March 2019) was inspired by Hiim and Hippe (2007) and more recently by Gynther (2010) and Hachmann et al (2014), who both integrate digital production and innovation into didactic considerations. “ROBOdidaktik” adds a concrete focus on digital production and methods in the classroom, as well as an orientation towards various aspects in the environment of the educational settings.
Organisation of the paper: first the didactic model is introduced, and then its four dimensions (teaching design, digital production methods, digital literacy and environment) are described in detail, supplemented with illustrative examples from the project crossingIT (2017-2019). The paper ends with a summary and conclusion.

[1]https://www.robo-sydfyn.dk/
[2]https://international.kk.dk/artikel/how-danish-school-system-structured
[3]https://www.crossingit.dk/

2. Didactic model for the development and evaluation of courses

This section presents a model for evaluation of teaching and lesson planning in programming, digital design and digital literacy. The model can be used for exploring all the relevant aspects in the design phases of a course and its further development. Furthermore, the model can assist in systematically evaluating existing courses.

The model was developed in collaboration with a selected group of teachers in the ROBOlearning project. In three workshops and several project seminars, the teachers explained their approach to planning and conducting teaching in digital literacy and production. They explained their ideas in keywords and provided elaborate examples of planned and conducted teaching in the field. In the ROBOlearning project, the teachers are now documenting their teaching using the four elements in the model. As a supplement, we developed questions to support and operationalise the model. Supportive questions as well as courses can be found on the project's website.

In the development phase, a round as well as a linear phase model illustrating the four elements was presented to the teachers. They preferred the round model. Learning and teaching is often circular, iterative and complex. The round model underlines that the starting point could be anywhere. Additionally, the model balances a technology and learning goal-driven approach by presenting complementary approaches to didactic planning.

Teaching computational and digital literacy is often driven by new exciting technology; this is referred to as "technology-driven teaching" (Majgaard, 2010). Teachers and researchers often mention that there should more to this type of teaching than exploring a new digital gadget. The teachers find it hard to achieve specific educational objectives by simply exploring a new gadget. As a contrast to the technology-driven approach, there is teaching driven by educational goals and learning objectives. The strength of the goal-driven approach is that the teachers know exactly what they are aiming for and when to stop, and they continue until the goals are reached. The disadvantage of this approach is that the teachers focus too much on the learning objectives and may become unable to adjust the goal(s) according to student progress and the potential discovered in the technology. The advantage of the technology-driven approach is the opportunity to explore new and untested technological breakthroughs. The disadvantage, on the other hand, is that the product may be useless.

Developing a new way of teaching requires that teachers balance conflicting priorities. When applying teaching technologies, the learning goals obviously have high priority, but learning only occurs if the students interact correctly with the technology and the technology is appropriate (and cheap enough for schools to afford) (Majgaard, 2010).

This new didactic model proposes acknowledging and balancing the technology-driven approach with the learning goals- driven approach.

The model introduces four dimensions: (1) teaching design: the traditional didactic dimension, covering aspects such as the identification of learning objectives, learning activities, practical organisation and evaluations; (2) digital production: this covers development methods such as iterative design cycles, pair programming pedagogy and the production of video tutorials as well as textbooks; (3) digital literacy: this dimension includes computational thinking skills, ethical approaches, critical thinking and societal perspectives; and (4) the environment, which encompasses co-creation with local companies or other educational institutions, and promotes career learning by gradually involving a wide range of environments into educational processes (Law, 2010). See figure 1 below:

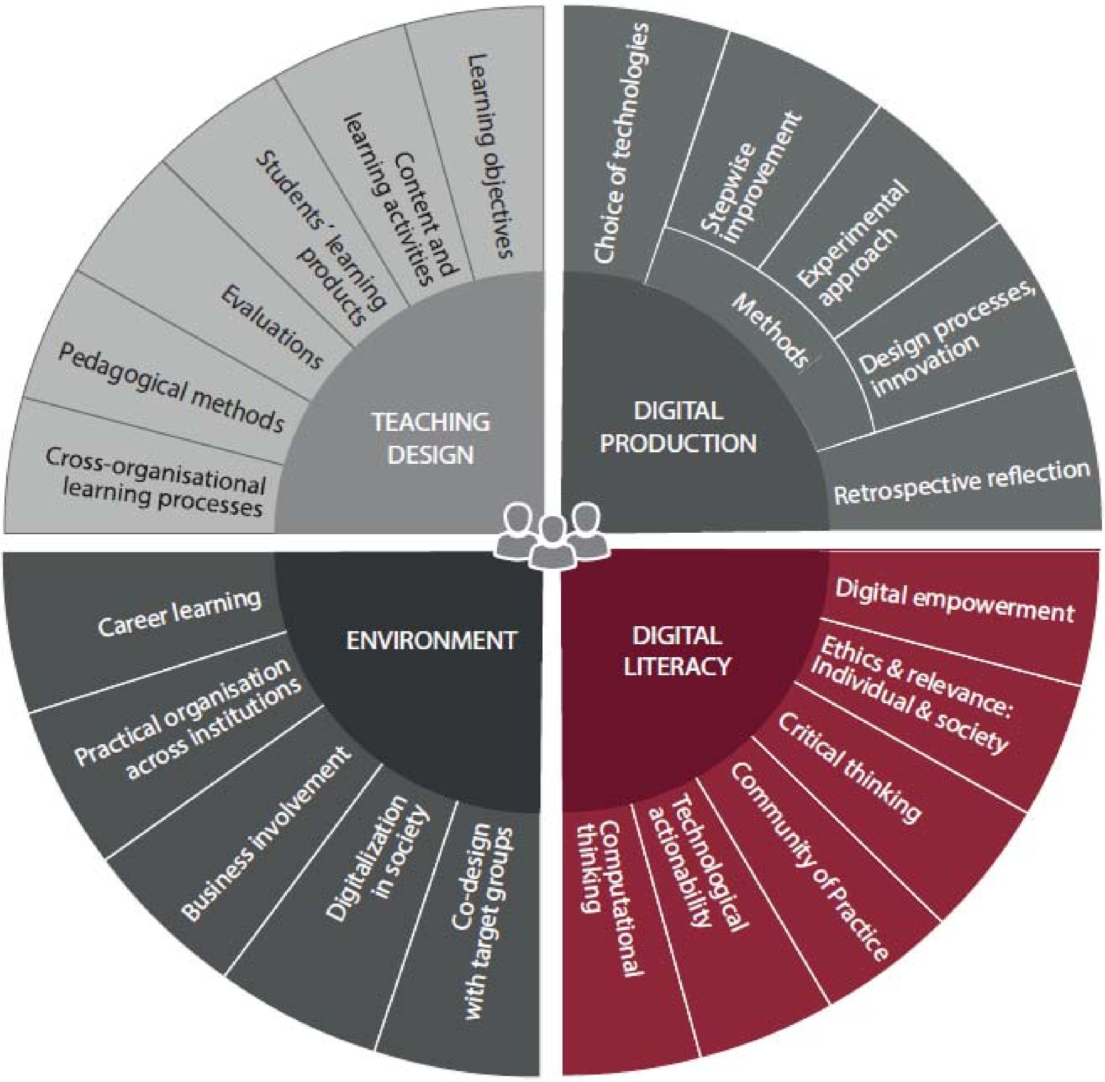


Figure 1: Didactic model for teaching in the field of digital production and literacy, for Danish original, see robo-sydfyn.dk (2019)

3. Teaching design (1)

Teaching design includes common elements of lesson planning such as learning objectives, activities, scaffolding and practical organisation: see figure 1. In addition, the teacher must decide on the learning output the students must produce and how it should be evaluated (Gynther, 2010; Hiim and Hippe 2007). Traditionally, learning output includes written texts (such as reports) and oral presentations. When the subject area extends to IT and technology, the products become more multi-faceted and often digitally interactive. They may include homemade computer games, digital simulations, apps, programs, code examples, student-produced video tutorials, robotic artefacts, video material explaining the students' digital products, etc. The teacher should formulate specific requirements for these digital products (for example in games: the number of levels, start and end scenes). In addition, the requirements can relate to a thematic framework such as, for example, climate or future scenarios.

Example: the local "World Championship in game design" in Svendborg, Denmark, took place over four days as the second iteration of an elective course for 150 7th-graders (13-14 years of age – lower secondary school) and 75 first-year HHX students (17-18 years of age – upper secondary business school).[4] The goal was to develop computer games in groups of four lower secondary school students, each group supported and supervised by two HHX students. A small group of HHX students also assisted as event coordinators. The learning objectives

[4]https://www.crossingit.dk/erhvervsgymnasier/uvforloeb-gym/

for the lower secondary school students were competencies in block programming, coupled with learning objectives in Danish and marketing. The learning objectives for HHX students included dissemination of academic material, mentoring of younger students, event coordination and organisation, as well as the production of teaching materials, in the form of 15 video tutorials. The course ended with a competition of student presentations in an auditorium, assessed and awarded by a panel of judges.

All course materials were added to a Padlet[5]: the time schedule, video tutorials, the students' games, documentation, etc: see figure below.

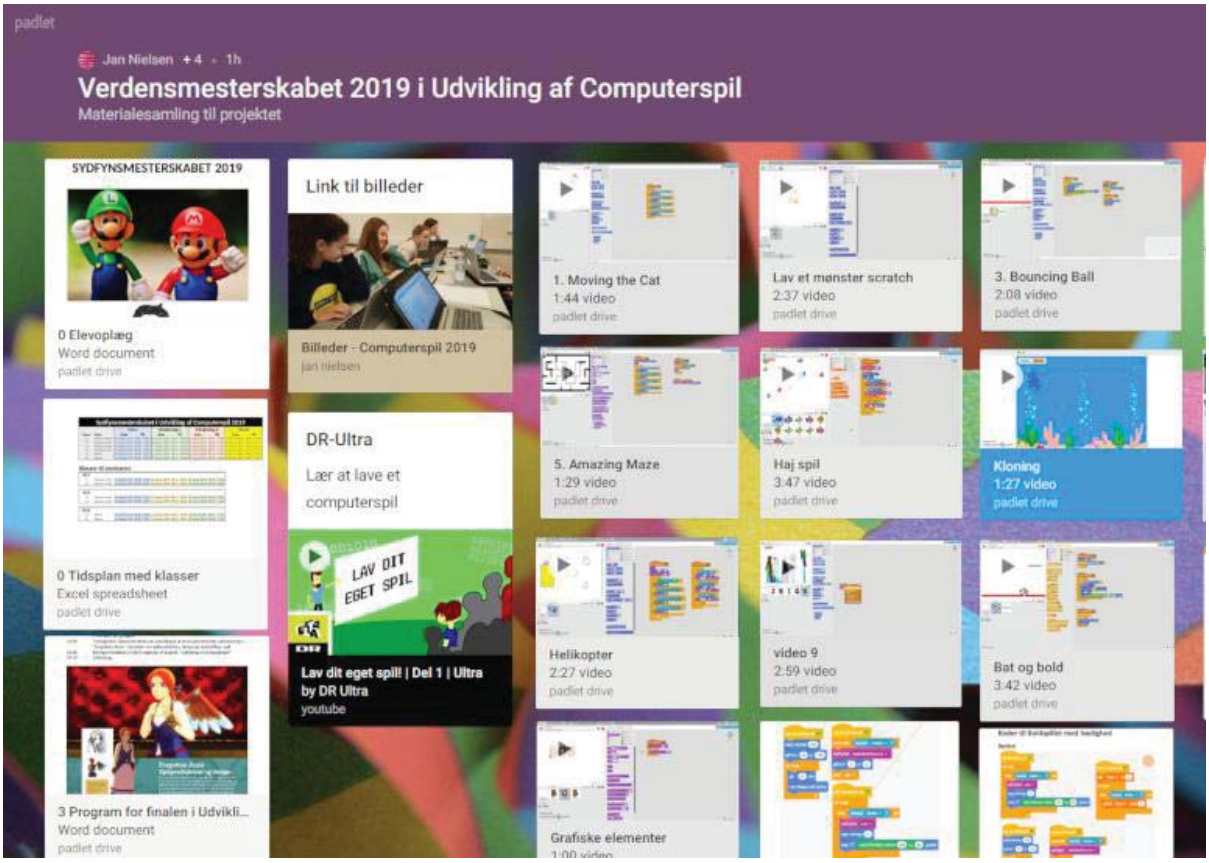


Figure 2: Open platform for teaching material

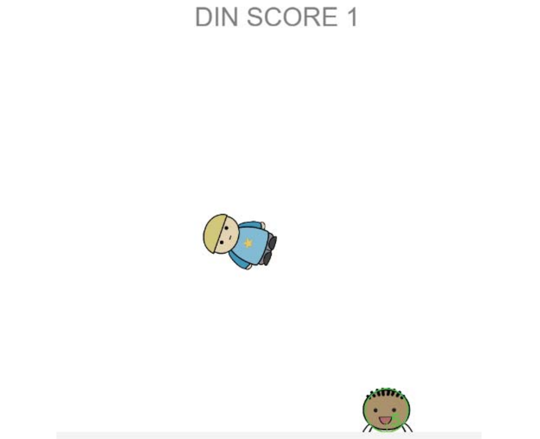
Optimally, the requirements for the games could have been worked out more precisely, for example with a start scene, three levels, end scene and score. The large-scale case can easily be downsized to a single class. The teaching design involved an impressive logistic organisation. The local schools are now planning a third iteration of the championship in game design.

4. Digital production (2)

The dimension of digital production consists of methods for digital production, e.g. well-ordered problems, well-prepared running codes constructed by the teacher ("worked example" Caspersen et al), video teasers, all of which form the basis for the students' products. It is important that the students not only copy the "worked examples", but that the running examples should kick-start their own further digital production. The examples ensure that all students get a head start, avoiding some of the frustrations and avoiding "getting stuck" from the start. There is, however, also a risk that over-developed examples block creativity (Majgaard, 2017). In other words, the worked examples should create a low floor and a high ceiling (Brennan and Resnick, 2012).

Example: Worked example. The teacher developed a simple running game on the platform code.org, which was shared via the intranet with the students: see figure 3 (a). The students developed in groups their own versions of Christmas games. In some of the students' games, presents and coal fell from the sky and Santa Claus had to collect the presents: see figure 3 (b).

[5]https://padlet.com/jni5/Computerspil



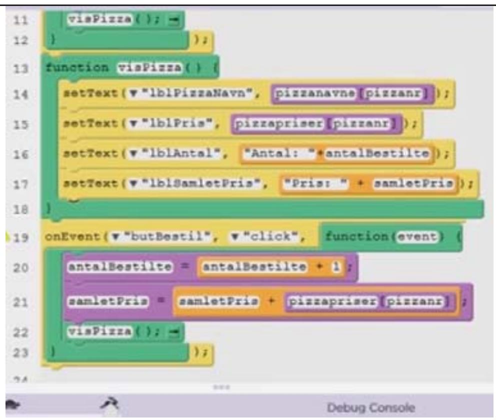
3 (a) Worked example developed by the teacher

3 (b) Student game based on teacher´s example

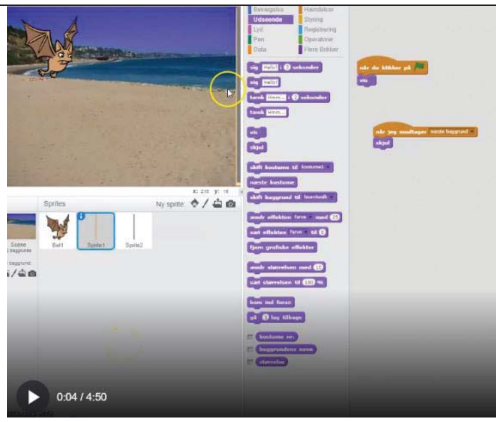
Figure 3: Screen shots of running versions of the worked example and student game (Business College Syd, Sønderborg 2018)

The running version of the game inspired and benefitted many of the students, although in different ways. But some of the technically advanced students preferred to work in a more experimenting way, without templates and using their own more professional software. It was easier for the teacher to supervise more uniform projects. On the other hand, this could have led to less creative solutions.

Example: Video tutorials. Video tutorials can be found online, and they sometimes match the learning objectives. Often teachers create their own tutorials that fit their specific curriculum and where the teacher acts as the expert: see figure 4 (a). Video tutorials can also be student products: see figure 4 (b). The students train the presentation of academic concepts about programming, producing a new running program at the same time.



4 (a) Video tutorial on pizza ordering system developed by the teacher[6]



4 (b) Video tutorial developed by a student[7]

Figure 4: Screen shots from video tutorials created by teacher and students

Video tutorials have proven to have great advantages: In video tutorials, the learner observes the functionality of the programming environment, which often is not explicitly articulated by the voice in the video. This show-and-tell approach is related to the concept of tacit knowledge (Majgaard and Lykke, 2018; Nonaka 1995). Tacit knowledge is rooted in actions, procedures and routines. Tacit knowledge consists partly of embodied informal knowledge that is hard to explain explicitly in words (Nonaka, 1995). Tacit knowledge is displayed visually in the interactions and system behaviour recorded in the video. Tacit knowledge on display is one of the greatest potentials of video tutorials (Majgaard and Lykke, 2018). On the other hand, there are also challenges associated with video tutorials; they may not match specific learning goals, programming environment versions can be obsolete, it can be time consuming to revisit specific parts of the video, the pace may be too fast, important

[6]https://www.youtube.com/watch?v=wIf8kbZ3T6c
[7]https://padlet-uploads.storage.googleapis.com/344941766/2f897a566fdd2812a8571236c35fef77/video_7.mp4

steps can be skipped, and they can be time consuming for students to produce and for teachers to review (Majgaard & Lykke, 2018).

Pair programming is also an effective method. Students sit in twos, programming and problem solving. At fixed intervals (for example 15 minutes), students change seats, so that it is not always the same students who sit in front of the computer and lead the way (Lui, 2006). This promotes a professional dialogue about digital production between the students, and more students participate actively.

Methods for iterative project development where groups of students experiment in freer settings are widely used (Fullerton, 2018). This requires a defined framework including pre-defined milestones, interim products, design phases and sometimes even team roles. A well-defined framework secures less chaotic design processes and classrooms. In addition, it provides the students with a framework in which they can move towards becoming creative designers.

5. Digital literacy (3)

The concept of digital literacy embraces the critical and reflected use of technology and digital sources, innovative thinking, and personal and societal positioning in relation to the role of technology. The concept includes critical use of social media, assessment of digital sources and application of IT-based tools. In addition, digital literacy includes practice-based methods for digital production and technological knowledge students gain by coding simple simulations themselves (Brennan and Resnick, 2012; Majgaard, 2018).

Digital literacy is, however, a broad and slightly imprecise concept. Sometimes it can be merely defined as possessing predominantly technical competencies (Brennan and Resnick, 2012; Gee, 2013). At other times, its definition extends to professional socialisation and innovative design competencies (Martin, 2008). Technical competence increases with the ability to engage in critical analysis of digital data (Buckingham, 2008). Martin (2008) has attempted to relate these elements to each other. His model focuses primarily on the use of technology and less on the design and coding of new digital applications. Table 1 below is inspired by Martin (2008) and has a focus on design and coding. The three perspectives described are the personal perspective, the perspective of community of practice and the digital production perspective.

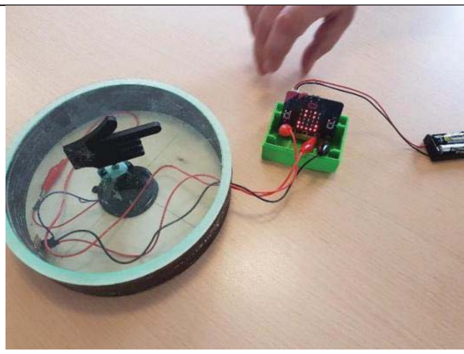
Table 1: Digital literacy from three perspectives (Majgaard 2018; Martin, 2008)

Digital literacy from the student's personal point of view: The critical and reflected user: *Understands the importance of IT security, e.g. encryption, privacy, authentication, identity theft, etc.* *Understands the unwritten rules of social media, for example when acting as Influencers* *Understands how to identify and select credible digital sources* *Develops meaningful content using the rich resources of the Internet.* The creative and innovative designer: *Dares to undertake technical experiments* *Develops new ideas, concepts and prototypes* *Combines techniques and skills in new ways based on personal preferences.* The critical and reflected citizen: *Is aware of technology in society and its social effects* *Is open to the development of technology to support society* *Sees the uses of technology in coping with global challenges such as pollution, climate change, security and crime* *Is mindful of ethical issues.*
Digital literacy in the community of practice perspective: *Digital technology used in professional practice at work or in the classroom.* *Roles* *Tacit knowledge: digital practices are sometimes transmitted in actions that are not expressed in words, for example: handling of a programming interface or a word processing application.*
Digital literacy from a digital production perspective: *Understanding and mastering programming and technologies* *Knowledge of algorithms including loops, variables, methods etc.* *Knowledge of the order in which the code and algorithms are executed* *Design of code structure* *Testing and troubleshooting*.

The personal perspective is the most complicated aspect, as it requires critical and reflected thinking on rather complex and complicated subject matter such as IT security and how information is spread on social media. At the same time, the students are expected to choose credible sources of information in order to acquire new knowledge: see table 1. Creativity and innovative skills are often expressed in ways that reflect the individual. New ideas emerge from personal interests, beliefs and skills. For example, some university students chose to develop an intelligent shoe for elderly people with dementia, while other students chose to develop digital props for role-playing games. Both groups used the same sensor technology, and their projects became equally technically complicated. The group developing the intelligent shoe added a societal component to their idea – this illustrates the reflected citizen perspective of the model.

Example a: Creativity and personal viewpoints. In the game competition, the 7th-grade students won with a game about collecting plastic in a polluted world visualised in various levels: see figure 5 (a). The game idea reflects the students' viewpoints and their need to create meaning in their student products. Another group of upper secondary students developed more open projects and one of these was a turn-taking robot game involving a finger was randomly pointing in different directions: see figure 5 (b). Often students chose to make digital versions of analogue games.

5 (a) Student game about collecting plastic in a polluted world



5 (b) Robot student game involving a finger pointing randomly in any direction.

Figure 5: Student products reflecting students' personal viewpoints

Example b: Social media. In another example, students analysed product placement in influencer videos and developed their own simple commercial model.

Example c: Ethics. Students were introduced to the "trolley dilemma" and were asked to address the subject of driverless cars. The students had to decide which pedestrians to save in a complex traffic situation[8].

Digital literacy in the perspective of community of practice refers to the role of technology in, for example, the classroom, where teachers use video tutorials to supplement teaching materials: see table 1. The students find video tutorials on their own to supplement the official textbooks. In addition, groups of students often develop new digital prototypes in the community of the classroom (Lave and Wenger, 1991).

Finally, digital literacy from a digital production perspective: the students are taught to code, see table 1. Often digital production skills are described as computational thinking skills (Brennan and Resnick, 2012). Digital literacy includes iterative development of knowledge and practical skills on algorithms formed by lines of code including loops, statements, variables, communication with keyboard input and output screen etc. Gradually, the students learn to correct their code by trial and error (Bateson, 2000). The programming environment acts as an object to think with, since it immediately responds to the programmer's new quirks (Papert, 1994).

6. Environment (4)

The fourth dimension, the environment or outside world, involves, among other things, career learning (Law, 2010), business collaboration and cooperation between different educational settings.

Educational choices and career planning are often undertaken far too randomly, dependent on social expectations or conditions and (a lack of) role models. This is indicated by the fact that too many young people drop out of their educational programmes or make choices based on tradition, such as gender-biased choices.

[8]https://arkiv.emu.dk/modul/trolley-problem-%e2%80%93-en-etisk-dilemmaleg

At the same time, there is a need for rethinking careers to meet the future challenges of a globalised and strongly technology-influenced labour market.

In this unpredictable and fragmented world, educational institutions can create more connectivity and more transparency by strengthening the "educational chain" from primary school via secondary school to higher or further education (Danish Government, 2017). Learning objectives and academic fields can be coordinated across the educational levels to a far higher degree. Didactic approaches to ease transitions can be shared. Learning activities such as "bridging courses" from lower secondary schools for grade 8 students (Denmark) do not only prepare young students for the learning conditions and content in secondary schools, but they also illustrate various career paths.

Coding and programming offer great possibilities for being practised with a wide range of technologies and for advancing from grade zero to PhD-level. But the young people involved must experience a sense of cohesion and logical progression in the learning process.

Career learning is a newly emerged concept that includes the development of stage-by-stage self-propelled control of the learning process (Law, 2010). Career learning methods promote learning processes towards making sustainable choices for personal pathways in education and work life.

Ideally, input to student projects comes from real-life and practice-based problems supplied by companies or the trades in general. From time to time, companies are invited to present concepts or evaluate projects in secondary education. The idea is that collaboration with companies and universities inspires and widens the students' personal perspectives and helps them to make more informed decisions on their career choices. The cross-organisational collaboration and work-based learning clearly motivates the students.

Example: In the World Championship example, the students from upper secondary school met and supervised students from lower secondary school on the upper secondary school premises. In Denmark, secondary schools are physically separate from each other and the students have to choose which upper secondary school to apply to, dependent on competencies and interests. The championship event broadened the lower secondary students' knowledge of local upper secondary education.

7. Summary and conclusion

This article has introduced a model that highlights some of the typical issues involved when introducing coding, digital design and digital literacy into lower and upper secondary schools. All examples are taken from the crossingIT project. More information can be found in Danish at www.crossingit.dk.

In the planning phase 1, the teaching design requirements for the digital product must be specified. Phase 2 (digital production) encompasses the production method and how the production method will be conducted.

The digital literacy table (see table 1) for phase 3 is not complete, but it provides examples of the three aspects: the students' personal point of view, the community of practice, and the technical level including computational thinking. A single course can typically not cover all these aspects, but, over time, the teacher can tick off more and more aspects and perhaps even add new ones.

The fourth dimension - environment - is crucial in secondary education, because the students must make decisions about their final education and profession beyond secondary education. They have to acquire knowledge of the world outside of school and family. Involving companies and other educational institutions promotes the students' career learning. This is also a part of didactic course planning.

Development and application of the didactic model will continue in the coming years in the ROBOlearning project. See more at https://robo-sydfyn.dk.

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