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Master's thesis in Computer Science
Supervisor: Monica Divitini
June 2019

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Abstract

Technology is continually changing, and there is a growing need to educate the new generation so they can be a part of the digitalization that is happening. There are educators both in and outside of school that define learning activities for their students. These need to be supported through the process. Tinkering is a teaching approach that lets students explore technology and develop their understanding of a subject. This is done by having students go through an iterative process where they fiddle with tools to solve a problem — defining a problem where the students' tinker can be time-consuming and challenging for educators. However, running this type of activity can help children develop their higher-order thinking skills. Through interviews, it was discovered that educators seem to be having success with implementing tinkering problems in their classroom, but the literature shows that there are still many challenges when it comes to planning this type of problem for the classroom. There already exists platforms that aim to support educators. A selection of these platforms were analyzed, and it was discovered that there is a lack of support for educators in the process of defining activities.

In this thesis a conceptual model that illustrates the process an educator have to go through to define an activity with tinkering was developed. This model gives an insight into what sub-processes the educator has to be supported through. The main results add to previous knowledge by providing a model which adds an understanding of how to implement support in this process of defining an activity to a platform at a conceptual level. It focuses on the definition of a specific type of learning activity that includes tinkering. The results aim to illustrate how a platform can help support educators when they are going through the process of creating a tinkering based programming activity.

Sammendrag

Teknologi er konstant i endring og det er et stort behov for å utdanne nyere generasjoner slik at de kan delta i digitaliseringen. Lære som jobber både i og utenfor skolen har et ansvar om å lage læringsoppgaver til elever. For å gjøre dette trenger lærerne støtte i prosessen med å lage oppgaver. En metode som kan brukes er å la barna lære gjennom utforsking, og la de fikle med teknologi for å utvikle deres forståelse av et emne. Dette kan gjøres ved å la elevene gå gjennom en iterativ prosess hvor de utforsker og bruker teknologien til å komme opp med løsninger på et problem. Det å lage en slik oppgave hvor elevene får fikle kan være tidkrevende og utfordrende for lærere, likevel øker denne typen oppgaver barns metakognisjon og gir dem en økt forståelse av hvordan ting fungerer. Gjennom intervjuer ble det oppdaget at ulike lærere har hatt suksess med å implementere denne type oppgaver. Litteraturen avdekket derimot at det finnes utfordringer ved å bruke denne metoden i klasserommet. Det finnes allerede eksisterende plattformer som er rettet mot å støtte lærer i klasserommet. Noen av disse plattformene ble analysert og det ble oppdaget manglende funksjonalitet for å støtte lærere i prosessen med å lage læringsoppgaver.

I denne masteroppgaven ble en konseptuell modell laget, som illustrerer prosessen læreren må gjennom for å lage en oppgave med læring gjennom utforsking. Modellen gir et innblikk til hvilke delprosesser lærere kan bli støttet i. Resultatet av oppgaven og modellen tilfører kunnskap gjennom denne modellen som viser hvordan man kan implementere støtte til lærere i prosessen med å lage læringsoppgaver på et konseptuelt nivå. Det fokuseres på definisjonen av en spesifikk type oppgave som inkluderer å lære gjennom utforsking. Målet med resultatet er å illustrere hvordan en plattform kan hjelpe lærere når de går gjennom prosessen av å lage en læringsoppgave som fokuserer på utforsking.

Preface

This submission is my master thesis submitted to the Department of Computer Science at the Norwegian University of Science and Technology (NTNU). The thesis concludes a five-year Master's degree program.

I want to thank my supervisor Monica Divitini, for the invaluable input and feedback throughout this project. Your feedback has helped guide my work and kept me motivated through the writing process.

I would also like to thank:

- The experts who took the time to be interviewed for this project, your feedback has been invaluable
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Trondheim, June, 2019

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Chapter 1

Introduction

1.1 Motivation

There is a growing need to educate the new generation about technology so they can be a part of the digitalization that is happening in the world. The Norwegian Ministry of Research and Education has introduced programming as an optional subject in lower secondary schools [18]. Reasoning that not only does Norway want to be a part of this digitalization that is happening, but also that students need to know how these technologies function to keep up with the changes in society. Those in charge of educating the students will be teachers and educators inside and outside of school.

In this process, there is a need to support educators. A number of lower-secondary school teachers have confessed that they feel they are not getting the support that is needed to teach programming [18]. There are not only teachers but other organizations outside of school that aim to teach children programming. Organizations who both aim to reach children who are already interested and some who aim to get children interested in the subject. Some of the instructors in these organizations do not have formal teacher training. This shows that it should be a focus on supporting these educators in the process of creating activities for their students.

Previous to this master thesis a specializations project was conducted [9]. Here educators and technology experts were interviewed and the data collected from these interviews were used to identify the challenges and needs of educators. The higher-level requirements presented in Section 2.2 were created based on this data. One of these higher-order requirements were 'HR5 Support Educators'. It says that a system or other solution focusing on educators should make it easy for them to use such a system. To make it intuitive to learn and use, and provide enough functionality to help educator in the process of planning a scenario or activity.

The interviews showed that educators were successful in incorporating tinkering in their scenarios [9]. Defining tinkering or problem-based learning (PBL) projects for a group of students is time-consuming, as these are not traditional classroom activities [13]. This can make educators hesitant to take time out of their day to plan these kinds of activities. However it has been shown, if executed right, that this form for problem-solving can help students improve their problem solving and higher-order thinking skills [21]. With some support when planning and implementing learning activities that focus on tinkering more educators can create problem-based, tinkering focused activities.

1.2 Context

This is a master thesis at Norwegian University of Science and Technology, continuing on from an autumn specializations project. In the autumn project data was gathered on the subject of supporting educators while creating scenarios for teaching programming to lower-secondary students.

1.3 Research Questions

Tinkering or Problem-Based learning lets students explore technology and develop their understanding of a subject. Instead of following plans on how to execute a task they use tinkering and fiddling to solve problems iteratively while defining their own goals. These methods have been showed to engage students and meet academic standards [9, 13]. Different students learn in different ways, and defining tinkering problems provides an alternative way for students to learn [21]. There is also the focus on showing that anyone can create something [10], which can help students become problem solvers [21].

The specialization project [9] showed that educators had good experiences with using tinkering in their learning scenarios and activities. It also found that educators needed more support when defining activities for their context. This was explored further in Chapter 3 showing that there is a lack of tools that support educators in the definition of activities. Therefore the main research question for this master thesis will be **RQ1**.

> **RQ1**: How can educators be supported when defining tinkering activities?

For the specializations project, it was discovered that there already exists some guidelines and suggestions on how to bring tinkering into the classroom [9, 10]. These guidelines and others will be explored further, as well as the exploration of how the information from these guidelines can be used to define a conceptual model. This is the reasoning behind the development of **RQ1.1**.

> **RQ1.1**: How can guidelines for tinkering in the classroom be used to support educators?

Other methods, that are not specifically defined in guidelines, on how to support educators will be explored as well. Looking at what challenges educators face and what techniques can be used to prevent these challenges from ruining the educator's project. This need for exploring more methods for supporting educators resulted in the last sub-research question, **RQ1.1**.

> **RQ1.2**: What other methods can be used to support educators while defining a tinkering activity?

1.4 Research Method

The selected research paradigm for this project was that of Design Science Research, which focuses on solving real-world problems by creating innovative artifacts. It involves two paradigms, natural science and design science[16]. Combining them to define theories and analyze, and later use the information gathered to improve upon information systems. The design science cycle is shown in 1.1. In the following sections it is described what has been done in each of these cycles. These answers are based on the design science research checklist presented in [16].

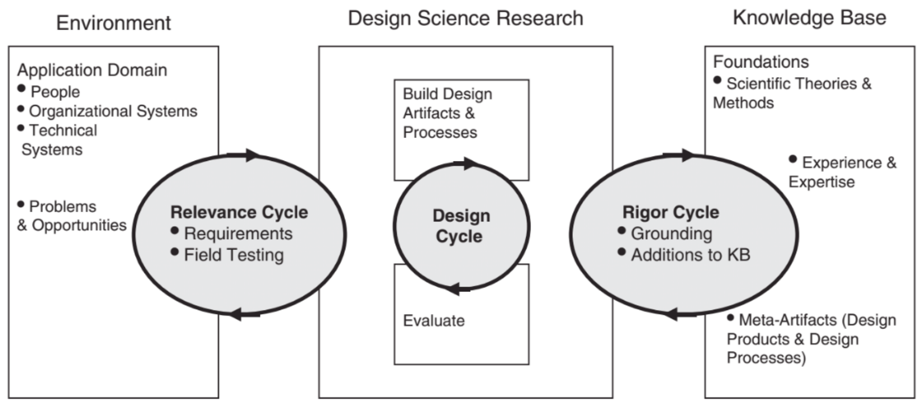

Fig. 2.2 Design science research cycles

Figure 1.1: Design Science Cycle as shown in [16].

1.4.1 Problem and Opportunities

The problem was identified based on the higher-level requirements defined in the specializations project [9]. It found a need to support educators when teaching programming, and to focus the work on how to offer them support. The specializations project identified that tinkering was a method that educators had success with. Therefore the choice fell on supporting educators who want to implement tinkering activities in their context.

1.4.2 The Artifact

The artifact designed in this project is a conceptual model that shows the process educators can be supported in when designing a tinkering activity. Additional tables that include identified problems and methods of supporting educators in the first three steps presented in the model were also designed.

1.4.3 Grounding

Information was gathered from the existing knowledge base. This information came from platforms that have functionality that is aimed towards supporting educators of programming and was used to look at what possible functionalities needed to be added to this kind of platforms. There was also conducted a literature review focusing on guidelines for tinkering, and that explored challenges educators meet and methods that can be used to support educators of programming with these challenges.

1.4.4 Evaluation

The project has been evaluated and defined through different processes. The first evaluation was done when needing to focus the application area of the problem. It had to be decided when educators should be supported, in order to find this an analysis of platforms was conducted. This analysis resulted in finding that there is a need for educators to get more support when they are defining an activity for their context. From this a conceptual model could be designed. As more research was done the conceptual model was re-visited and elaborated. The more research was read the more defined the conceptual model was made.

1.4.5 Introduction to Domain

The introduction of the artifact into the application environment have not been completed. The idea was to create an implementation of the conceptual model as a tool that could be complementary to already existing platforms for supporting educators. This will have to be further work.

1.4.6 Added Knowledge

The project has added knowledge to the knowledge base in three steps. Through the analysis of selected platforms aiming to support educators, it was found that there is a need lack of support for them when they want to create their own activities. An analysis of the interviews from the specializations project [9] define some methods used by educators who use tinkering as part of their activities. Lastly, a conceptual model identifying the process an educator has to go through to define tinkering activities was designed. In addition to the model supporting tables were created, these show suggested methods for overcoming known implementation problems. These three parts are the contribution of this project.

1.5 Results

As mentioned in Section 1.4.6, the result of the project have been defined in different parts of the process. The main contribution to the project is the Conceptual Model presented in Chapter 5, with the additional tables that show identified problems that educators need support with and methods that they can use to feel supported. As well as this contribution the analysis of platforms in Chapter 3 shows that there is a need for a solution that allows users to create their own activities with support. The analysis of the collected data from the specializations project also show that many of the educators had experiences with tinkering, and the methods they used for using tinkering in their context were gathered as a result of this analysis.

1.6 Outline of the Thesis

This first chapter presents the motivation for the project and give an insight into the research questions, the research method used and results the project produced.

Chapter 2 presents the previous work done in this project. It talks about data collected in interviews and presents higher-level requirements that were a result of these interviews. It also has an analysis of the interviews based on themes connected to tinkering and problem-based learning.

Chapter 3 is an analysis of existing websites with learning materials and guides for educators. It explores how they meet the higher-level requirements presented in the previous chapter.

Chapter 4 is a look at literature about tinkering and problem-based learning with a focus on guidelines and techniques recommended in the literature. It also maps out known challenges with implementing these type of problems in the classroom.

Chapter 5 presents the design process of a conceptual model that shows the identified process and sub-processes of creating a learning activity with tinkering as well and supporting material.

While Chapter 6 summarizes the thesis, discusses answers to the research questions and suggests possible future work.

Chapter 2

Problem Elaboration

One of the themes that came out of the interview done for my specializations project [9] was the use of tinkering when teaching programming. They showed that many of the educators had good experiences with letting the students tinker in the classroom. Tinkering is an approach that can be used to enable students to explore and learn about technology [10]. It requires the educator to introduce students to a new problem instead of defining a step-by-step guide on how to create a product. This approach lets students learn through experimenting and developing their hypothesis and knowledge about a subject. The process of tinkering is playful and iterative, as students define their goals based on their explorations [21]. An example of a tinkering problem is letting students figure out how to make a piece of cardboard float over a blowing fan through experimenting with different solutions [10].

Problem-Based Learning (PBL) is a similar approach where students learn through solving a real-world problem. This approach is student-centered, and students are required to collaborate to be able to define and solve the problem [17]. The main focus of PBL is on improving the students higher-order thinking skills and promote understanding of the subject[12]. PBL focuses on self-directed learning, and having an educator who is an excellent facilitator is an essential part of making the PBL approach successful.

The results from the analysis of platforms that provide support to educators from Chapter 3, shows that there is limited support for educators when creating learning activities. Focusing on the lack of support of educators, with the focus on creating tinkering activities is something that should be explored.

The main focus of this thesis will be to look into tinkering guidelines and similar methods to identify ways to support educators in the creation of tinkering activities. Then use this information to create a conceptual model that supports educators through the process of creating an activity. A model that can be used as a base when implementing support for educators in creating a tinkering activity to a platform for educators.

2.1 Previous Work

How educators structure programming related learning scenarios was explored in the specializations project [9], and interviews with technology and educational experts were conducted. These were semi-structured interviews and thematic analysis, a qualitative method, was used to analyze the replies. Prior to the interviews, while researching the creation of learning scenarios materials that educators can use to define learning scenarios were explored. These included Lær Kidsa Koding (LKK) [4] that has a big database of tasks and teacher guides in Norwegian, Kodeløypa [3] a recruitment project at NTNU and UMI-sci-ed [7] a research project exploring Ubiquitous Computing, Mobile Computing and the Internet of Things (UMI) technologies. There was also a focus on the Norwegian school system and how they introduced programming in lower-secondary school and their aim to educate lower-secondary students about technology [18].

There was also an interest in exploring different ways to create scenarios. The focus landed on how learning by tinkering and IoT was used in projects when performing learning activities with students. The literature focused on multidisciplinary learning scenarios using Science, Technology, Engineering and Mathematics (STEM).

This information was used to create questions and conduct semi-structured interviews with 6 experts in the fields of teaching, programming and technology, and learning technology. By conducting a Thematic Analysis the data from the interviews were sorted into the following categories.s

- Educators of Programming
  - Educators Own Experience
  - Educators Sharing Experiences
- Tasks
  - Structuring Tasks
  - Availability and Re-Use of Tasks
- Criteria
- Learning Goals
- Use of Templates
- STEM and Interdisciplinary Learning

2.1.1 Learning by Tinkering and Mapping Activities to Curriculum

The categories under the headline tasks talk about how educators structure their tasks, and how they focus on meeting criteria and matching activities with learning goals.

Most educators had experience with having more than one level of difficulty in their scenarios. Commonly having a harder task to challenge the students and let them tinker with the technologies they were using. Allowing the students to define their own solution to problems.

The educators imagined different criteria when creating learning activities. These were used to map their scenarios and activities to the national curriculum (including Norwegian-, Finish- and Greek curriculum.)

2.1.2 Different Approaches to Creating Scenarios

Educators mentioned different ways of creating their scenarios. While some researchers used the UMI-sci-ed templates for inspiration and looked through already created scenarios, others used them as a checklist for creating their scenario.

There were also voiced interest in interdisciplinary learning. Both as it is being introduced into the Norwegian curriculum in both Math and Science, but also as a tool to engage a larger group of students.

2.1.3 Needs and Challenges of Educators

The needs identified in the end were the need for a variety of tasks, having resources that are available and a community to share experiences and ideas with.

The challenges identified were students motivation and hardware problems. As well as the importance of supporting teachers in developing their ICT-competences and the educator's problem of coming up with ideas for new activities.

2.2 High-Level Requirements

Based on the specialization project done in Autumn 2018 where higher order requirements were created based on interviews done with different educators. This gives an insight into what aspects a platform for educators who teach programming could focus on.

HLR1 Accessible Information

Information should be easy to locate. The user should be able to find information fast and easy. Therefore the system needs to have relevant information available. This also means that it should be easy to retrieve this information from the system.

HLR2 Easy to Interact

It should be easy to interact with the content, which includes learning activities, scenarios, shared data or other relevant data. It has to be able to add, find, and modify the content. There should be a possibility of saving and recording scenarios, as well as browsing and find different scenarios.

HLR3 Inspire Ideas

The system should help the educator generate ideas for scenarios. It should provide a starting point or at least inspiration for the user. It should be possible for the user to find other scenarios by browsing by e.g. themes or technologies. It should be possible to take parts of a scenario or be inspired by other scenarios and to create a scenario for their context.

HR4 Communication

The system should allow users to communicate. Users should be able to leave feedback on their experiences to record for later or share with others. Possibility of providing and getting feedback. Sharing scenarios with others, and the possibility to collaborate with other users.

HR5 Support Educators

The system should support the educator. It should be intuitive to use and the system should help the educator when he or she is planning a scenario for their context. IT should be easy to learn for non-experts (computer science). Teachers do not have much time to learn new tools, therefore it is important to focus on the usability and for the system to help the educator.

HR6 Available

The system should be available. It should be easy to find and use the system. It should be easy to reach the system, not require a lot of searching and waiting. Available on different platforms, browsers, operating systems or what else might be relevant systems. It should have resources that are available if the user is offline.

The system should be able to support a variety of content and the system needs to support a large amount of data without adding a lot of delay or other problems such as crashing.

2.3 Interviews Revisited with Focus on Tinkering

The data collected from the interviews done in the specializations project [9] was analyzed. This time the focus was on tinkering and tinkering-related topics. This theme was selected as an interest in tinkering was something that came up in most of the interviews. Another reason for the analysis was the results from Chapter 3, Section 3.8 the need to support educators more.

2.3.1 Purpose

The purpose of this new analysis is to identify how the interviewees use tinkering in their scenarios. To explore their experiences with it and identify what has worked for them. This data was collected so that it could be used in further design of a Conceptual Model for supporting educators who want to introduce tinkering activities.

2.3.2 Process

The data that was analyzed was from interviews conducted for the specializations project [9]. The interviews were conducted as semi-structured interviews. The questions were prepared before the interview and shared with the participants. This way they had the opportunity to reflect on the questions before being interviewed. The questions were designed to find the challenges and needs of educators teaching programming. There were six participants in total, and they were different educational experts, members of UMI-sci-ed, one participant from LKK and one lower-secondary school teacher. The interviews were recorded with a hand-held recorder that was not connected to the Internet. All the all interviews were transcribed in full length, and this data that was used to conduct the new analysis.

Thematic analysis was used to analyze the interviews [20]. It was done by sorting the interviews into what data was considered relevant for tinkering or tinkering-related activities. This data was then sorted into the categories that are presented in 2.3.3.

2.3.3 Analysis

Students motivation

Educators have to keep the students motivated and have to learn when to let them fiddle or to guide them. There is also a focus on finding topics that motivate the students.

Many of the educators had expressed frustration with students losing motivation at some point in the process. The first UMI-sci-ed participant talked about how students seemed more interested in their phones, and how they tried to include gamification and prizes to raise the student's engagement. He felt as if this was not sufficient, and that the team should invest more time in researching it. The teachers also mentioned how "lower secondary students are often a bit impatient."

Another approach by from the third interview, was the educators focus on finding a motivating topic from our everyday lives to focus on. Thereby finding the topic first based on what could be a motivating subject for the students. He formulated it as the question of "Can we find some kind of solution using the technologies that we have heard about or even used, that may motivate the students to this? [...] For me at least, is the way of generating the motivation in order to do something difficult."

The teacher had experience with having to find a balance between how much freedom they should have and how much she should guide them. Saying how "one should not leave it so that they fiddle too long, because these young students are impatient and they throw themselves into the work." Continuing with "It has also not worked to throw them too much into things to figure it out themselves. They will keep hitting a wall. So it is an in-between thing between throwing them out there, but also showing them some things. You must not teach too much in this subject, they need to be able to do."

One approach the first interviewee talked about was letting the students participating in a coding-club meeting have some freedom when following step-by-step guides to create a game. "We say that they get to pick for themselves which figure, background, et cetera, they want. When they are done, they can add extra functionality." The result was many different games, and the interview participant said that he ”I think this is a typically successful session when everyone starts doing things on their own premises after finishing.”

Methods of Implementation

Educators are using different methods to keep their students learning about programming. They mention the importance of being able to support their students in the process and how to achieve this. By creating guidelines, dividing tasks and their experiences with different technology. They had developed different ways to support their students and implementing tinkering.

Both the participant from LKK and the lower-secondary school teacher talked about dividing their tasks into more than one part. Firstly starting out by getting the students familiar with new technology, starting out small, and then having students solve problems on their own. LKK usually have four levels of difficulty to their tasks, where the first three are easier and the third one challenges the student ”by giving them instructions to create this, instead of saying 'do this, this, this.' Then we are expecting that they know a little already.” The teacher's approach was also focusing on teaching the basics first. She said that ”When I create tasks then it is to introduce new tasks an new things. It has to be to try on and off. Then bigger tasks, when they have learned new things. They will get the type of tasks where they can create a game in processing or create an animation.”

The teacher also talked about creating guidelines for her students, these could help both them and her when grading their work. One example task she mentioned was telling the students to create a commercial for something fictive. ”I set up some criteria for them, if not they create something very simple and that is not a very good achievement of the learning objectives like them having to use loops, etc. [...] I write down what needs to be included to reach the best grade. Then they can try their best. They get help and guidance underway, by all means.” These criteria could help the students and educator to guide their work.

Three out of the six participants also mentioned the importance of supporting all the different students. Some different techniques to keep all students included were mentioned. Adaptive learning systems, which means that students get learning materials based on their needs or, were mentioned. The teacher talked about splitting the class in two when the second year she had some students who were familiar with programming and some who were new to it. Dividing the class worked so that those who are new could learn about this first while the rest could experiment. Another way to support the students were to add extra challenges for those who finish early. Supporting students with different needs can be important, so all students get to achieve something.

Two of the technology experts talked about how they were using UDOO [6] toolkit provided by UMI-sci-ed in their scenarios. Both talked about this as technical challenges, and put it as ”the UDOO requires a fairly substantial amount of knowledge on how to use it” and ”that has also been much a challenge because we were not familiar with the tool.” One of them even mentioned that a solution could be to use another tool that was easier to learn such as the Arduino [1]. The lower-secondary teacher mentioned how one of their limitation with using toolkit was the knowledge of their existence. ”Such new technology they are not hard to get started with, it is fun, but they are things that I do not know about.” Evaluating and choosing the right technology from available technologies for a project is important.

Support Teachers

It is the teacher's jobs to know what is relevant or not for their students [18], and need to be supported in this process. In school, teachers have to follow the national curriculum. Educators also have limited time and have to decide how to allocate their time when creating activities or exploring and learning new material for their next projects.

Teachers need to filter what is relevant or not for their students. The interviewee from LKK talked about how they try to map tasks to the current learning objectives in Norwegian schools when they create tasks that focus on schools. The Norwegian teachers spoke about how she ”looks if they [tasks] are smart to use for students. [...] I like to know that what they [the students] are doing is helping them learn something useful.” Mapping activities to these learning goals in the national curriculum were something the interviewees working directly with students found important.

Educators have to see what use a tool can bring them, without spending all their time. Both the expert on educational technology and the participant form LKK agreed that ”the teachers have to see like every other user, what is the immediate usefulness of what you are doing for them,” and that ”teachers are very busy.” There are different areas that are important, depending on the situation. It can be the need to see ”how will this make them serve the learning goal better,” as said by the educational technology expert. It can also be that when they ”are including something that they do not know already, it is important for them to easily see what it means, involves.” Showing the immediate usefulness of a tool, and that it easily supports an educator can help it from becoming too time-consuming or hard to use.

Two of the UMI-sci-ed researches who created scenarios for students in lower-secondary school found it important to improve the students thinking skills. This through introducing scenarios with different levels of difficulty. The educational expert from this project explained how they ”[when we were] designing these scenarios, we were thinking that these had to improve the students thinking skills as well.” If used right problem-based learning or tinkering problems can help improve learners thinking skills [21].

2.3.4 Success with tinkering

When asking participants what they considered successful scenarios two of them responded with similar answers. The teacher from lower-secondary school also talked about how she ran projects with open descriptions that lasted over a long time, and where students had to create their own solutions. Some of the most successful experiences for two of the participants will be quoted in this section.

From the first interview with a participant form LKK, he talked about one of the scenarios he found most successful. He said ”the most fun we did was when we had a competition for those [the students] who had participated in our course. They had been through 5 to 6 to 7 weeks course in scratch [5].” They let the students make exactly what they wanted and record the process, and the team from LKK would pick three winners. These winning activities would be re-written by LKK team members and published on their website under the name of the students who created them. These are now published on their website and is being used for LKK courses and in schools around Norway. ”They were so happy, and it was so much fun and [they, the students] have showcased it [what they created] and been proud of it. It was maybe the most educational session they have ever had when they created the activities themselves.” The participant from LKK concluded with. The LKK used prizes to motivate students, and they had students who already had some experience with the tools they were required to use. This resulted in what the LKK participant perceived as a successful experience.

From the third interview, the participant that was part of the classroom implementation talked about the scenario he found the most successful. ”I think the scenario that we did not design, but the students came up with was nice. We build weather stations on the rooftop. It did not work out that well, as they were not aware of the wind. But it was something that was really quite fascinating. The students came up with that idea and were really motivated to do it, and it was a stem scenario they came up with themselves. That was something that worked really well. The others, yeah, I don't know, I think that was the best one experience-wise.” This participant had designed scenarios for UMI-sci-ed before. However, the one he found the most successful was the one the students themselves designed.

2.3.5 Results

From this analysis, some techniques that educators use when using tinkering in their scenario were identified.

It showed the need to focus on students motivation. Methods that were successful in keeping the student's motivation was a combination of many factors. Gamification could be used and presenting prizes to winners. Focusing on the life of the students and their interests, and using this to find motivation for projects. Opening up activities towards the end, so that students can continue to be motivated even after doing most of the work. Challenges identified with students motivation were that educators have to find the balance between showing students how things work, and throwing them into the action and letting them figure out how things work.

When it came to implementation of activities methods that had worked for the participants were to divide tasks into different parts. By starting with more manageable tasks and introducing new material, the students could later get more challenging activities that allowed them more freedom to come up with their own solutions. Another method was for the educator to create the problem description and guidelines for what should be included in the solution. This gives the educator support when they are grading the student's works and support both educator and students when solving the problem, by knowing what to focus on and what needs to be included. The last found method was to support the different learners; not everyone has the same knowledge and learn at the same pace. Examples of ways to do this was to introduce extra challenges, dividing the class, or using adaptive learning systems. A challenge discovered with implementing activities was knowing what technologies existed, having the technology available, and choosing the correct tools for an activity.

When using tinkering with students, the classroom structure can be different from what educators and students are used to. This can mean educators need more support and that the educators need support to support their students. Methods to ensure support can be to have tools that show their immediate usefulness and tools that show how educators can meet their learning goals. Also having tools that, in some way, help the educators support their students to improve their higher-order thinking skills.

Chapter 3

Analysis of Existing Platforms

An analysis was conducted to explore how selected platforms fulfilled the Higher-Level Requirements presented in Section 2.2. The goal of this analysis was to explore which of the requirements were being met. Another goal was to identify what functionality were lacking in these platforms when it came supporting educators.

The focus was on platforms that are available on the web. These are easily accessible by users who have a web browser, and it was important to find platforms that provided functionality to support educators. Three platforms were selected, and these were the Norwegian Lær Kidsa Koding (LKK), the British BBC micro:bit and the international research project UMI-Sci-Ed's UMI platform.

3.1 Criteria for Analysis

The criteria presented in this section were used when analyzing the platforms. For each of the requirements, there was prepared a list that was used to analyze the different platforms. Each of the items in the list were based on the description of the Higher-Level Requirements from Section 2.2 and all items are considered equal. The heading of each list corresponds to one of the requirements described in Section 2.2. This method was selected as it provided a structured way to analyses three platforms based on the same criteria.

Accessible Information

- ☐ It should be easy to find information (it should be fast to access, require few clicks)
- ☐ Information should be relevant for educators (scenarios, activities, how to use the provided content)

Easy to Interact With

- ☐ It should be possible to add and modify content

- ☐ It should be possible to save scenarios
- ☐ It should be possible to browse content

Inspire Ideas

- ☐ It should be possible to view activities created by others
- ☐ It should be possible to browse activities
- ☐ It should be possible to create own scenarios based on the available content

Communication

- ☐ It should allow for communication in some form
- ☐ Users should be able to leave feedback and personal experiences
- ☐ It should have functionality for sharing and collaborating on activities

Support Educators

- ☐ It should be intuitive to use (easy to learn, not require a lot of time, possible to see relevant content fast)
- ☐ It should be easy to use (the user should not make a lot of wrong clicks and get frustrated)
- ☐ Functionality to create activities and scenarios
- ☐ Have material such as teacher/ educator guide

Available

- ☐ It should be easy to locate (if it is an app it should be easy to download, possible to find through a search or on social media, etc.)
- ☐ It should be able to support different platforms (available to many users, different operating systems and mediums)
- ☐ It should be able to support a large amount of data w/o slowing down (performance)
- ☐ There should be an off-line or download option to access the content

3.2 Selection of Platforms

The platforms were selected based on their different sizes and focus, as well as they are all available directly on the web. Both micro:bit and LKK are large resources that provide learning activities to students and guides for educators. The micro:bit is a tool that is used internationally, while LKK is a national, widespread organization that covers a lot of Norway. UMI-Sci-Ed was also selected as it is a research project that has pre-defined templates for creating learning scenarios and templates and have a focus on promoting Science Education for children. The content of each of these sites vary, and there was an interested in finding out how the different ones covered the Higher-Order Requirements.

3.3 UMI-Sci-Ed

UMI-sci-ed is a research project focusing on using new technology to promote Science Education for children in the ages 14 to 16[7]. It focuses on exploring Ubiquitous Computing, Mobile Computing and the Internet of Things (UMI) technologies. The project is an international collaboration between technological institutions and academic organizations. Some of the countries involved in collaborating are Norway, Greece and Finland.

The project has developed methodology and instructional tools that can be used when creating learning scenarios. These are presented as scenario templates and activity templates. A learning scenario consist of one or more activities[23]. The templates are for structuring the scenarios and describing them. They are of higher level and not very detailed in how to implement them in a classroom context. It works as a form that the researcher have to fill in, when the form is filled in the scenario is "defined." Therefore it is not aimed at just any educator.

There are two places to find information on this project *the Platform[8]* and the site for non-members[7]. This analysis will focus on the former.

Accessible Information The site itself is easy enough to navigate through. Creating new content, groups, scenarios, blogs, etc. each have their own link that is available at all times. However there are some expressions that does not seem to be explained if one are not already familiar with the UMI-sci-ed project. Example being the 'UMI project'- and 'Open Repository'-pages.

The information in 'UMI scenarios' would be the most relevant for educators. However these scenarios are represented in a template format that does not give exact descriptions on how to do each step of an activity. It provides an overview over what is required, what will be learned and ect. from doing a scenario. Some are better described than others. An example of a well described scenario is the 'IoT enabled recycling (Common Scenario)[1]'.

Easy to Interact with There is the possibility of adding content. Browsing is done through the search as is shown in figure 3.1. There is also the possibility to search outside of the categories.

[1] `https://umi-sci-ed.cti.gr/umiscied/?q=content/iot-enabled-recycling-common-scenario`

A user can join groups, which is a requirement to be able to create some of the new content for the site, such as a scenario. The creation follows the UMI-sci-ed templates. Other things that can be create are blogs, wikis, polls and more. A full overview is shown in Figure 3.2.

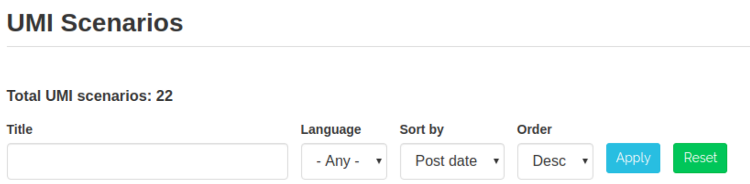

Figure 3.1: Search available on the UMI-sci-ed platform

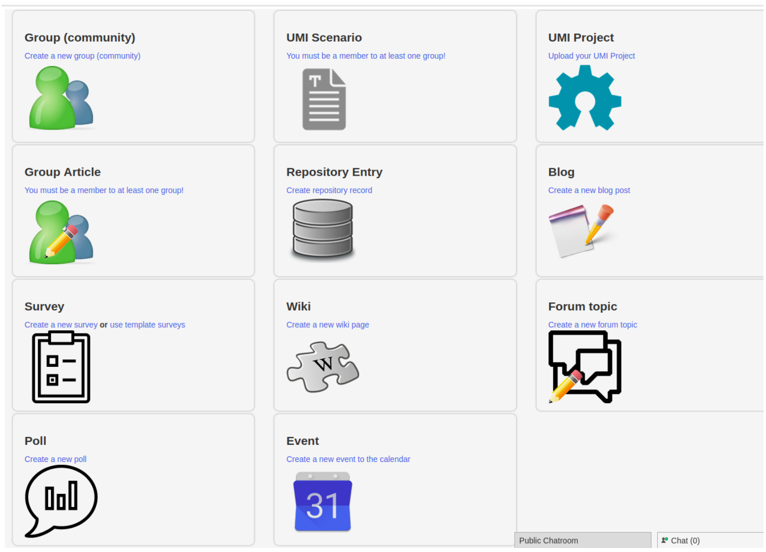

Figure 3.2: Site for creating new content

Inspire Ideas It is possible to view scenarios created by others and create new scenarios based on these ideas. Possibility to browse the content and to discuss in the forum, join groups dedicated to different subjects, and more. There are many ways to gather inspiration.

Communication The platform allows communication in many forms. There is a forum and a chat box that allows for conversations. Users are also provided with the opportunity to publish group articles, create and answer polls and comment on projects.

Support Educators To be able to create a new scenario you have to be a member of at least one group, this requires an administrator of a group to accept your request to join. The different content is created through filling out forms for polls, articles, etc. There are no specific guide that I could find that would support educators or non-expert users from UMI-Sci-Ed when filling in these forms and creating new content. However the functionality to create the content is there. One possible challenge is if an administrator is inactive on the site or have turned off notifications, then it would take a while before a new member is accepted into a group.

Available A user has to be created and then approved by an administrator to get access to the platform. If I did not know about this project, I would imagine it would be hard to locate as it is a particular platform that seems to be aimed at the UMI-sci-ed. There is a large amount of data already available on the site, in many different languages. It seems only to have an online option when using this tool.

3.4 Lær Kidsa Koding

LKK is a large Norwegian resource that aims to teach children programming outside of school, but their activities are also used by teachers in school. They arrange 'coding clubs' all over Norway that teach learning activities created by the volunteer members of the organization[4].

Their website, `kidsakoder.no`, is the main source for information, and it includes activities that anyone can access and work through. Each task in an activity has a checklist that students can check when they have completed the next step. For part of the tasks LKK also provide a 'Teachers guide'. These tell educators how it is possible to incorporate and teach the activity into schools, and how activities could correspond with the Norwegian curriculum.

LKK create their own tasks and have translated tasks from other resources. When creating their own activities they are written in a mark down language, this way all information comes out on the same format and it is easy for them to display on their website. It also makes it easy for them to generate pdf's of the tasks, for those who would like to print these or have them available offline.

Accessible Information The website for LKK have information that is easy and quick to find. There is a bar at the top of the page with relevant links, and there is information about the different services they provide, activities and more. The information is relevant for educators who want to teach programming to their students.

Easy to Interact with Navigating to the activities requires one click. It is possible to browse through the different activities as shown in Figure 3.3. Tasks are divided up and there are checkboxes provided for each step. There is no save button, but the website is built to remember which boxes have been checked. As well as remember if you are in student or educator mode.

They have a wiki[2] on how to contribute to their system, the link was provided through an forum post. The tasks are written in a mark-down language that one would have to learn, and one should be familiar with technologies such as the distributed version control system git[2] to contribute. It is therefore possible, but requires educators to use their time to learn at least one new technology.

Figure 3.3: Possibility to filter activities on LKK!'s website. The filter includes the opportunity to browse in scenarios or all activities. The user can also chose language, theme, subject and students year/grade.

Inspire Ideas It is possible to view activities and browse through the different ones based on level, language, theme and subject. There is no functionality that allows the user to build on already existing tasks, only suggesting improvements or create new ones.

Communication LKK provides communication in the form of a forum. From clicking around it seems to be mostly people asking questions and the members of LKK answering their questions. There are no discussions on the different activities they have available, but the forum is open so there is a possibility to do this. The forum is also used to inform about things the LKK are doing, such as informing about the creation of a GitHub wiki page on how to contribute content.

Support Educators It is easy to locate tasks on the site. From here there is a mode where one can select between student and teacher. Clicking on the teacher mode changes the colors of the layout, helping with separating the two modes. The tasks have a teacher-

[2] `https://github.com/kodeklubben/oppgaver/wiki`

guide that shows what one can expect the students to learn, how much time it will take, code that can be include in the students solutions and more.

There is no functionality in their website to provide support on how to create your own activities or scenarios provided.

Available Their website is easy to access, either through a search platforms or social media platforms. It is possible to download the tasks on pdf. The website loads fast even with a large amount of tasks and data available.

3.5 BBC micro:bit

The micro:bit is designed for computer education in the UK. It is now taken into schools in other countries as well such as Denmark and Norway[15][24].

It is a small programmable microcomputer. It supports both block and text-based programming languages and can be programmed through using a browser. It is aimed largely at schools, and the BBC has provided a large number of computers for free to students around the UK.

Micro:bit has an open source community which allows for a variety of resources. On their website, they have tasks aimed at children but also guides for educators using the device to teach programming or other projects.

Accessible Information Their website greets you with the opportunity to get started with micro:bit straight away. You can chose if you want to program or if you are a teacher. However after clicking around you are taken to different pages that contain a lot of boxes representing links. The external links seems to have a gray box while the internal links have a purple box around them. There is some information to be found on the page about the project.

Through navigating to internal links one can find Lessons and Projects. They appear to be on the same format, and both provide activities that are connected to each other in some way. Projects link to external tasks and lessons to internal tasks. After some browsing it was discovered that the pages that are titled Projects contain scenarios that are divided into activities. Where each activity has it's own link. One example being "Use the BitIO package to code Minecraft in Python![3]"

Easy to Interact with It is possible to find learning activities, most are links to external sites. These links can be browsed through the ideas page and the categories are shown in Figure 3.4.

There does not appear to be a way to add or modify content on this site. One solution would be to create something on an external platform and having it linked from the micro:bit site by sending it in via email. As they have this opportunity and write that "if you could contribute great resource please get in contact at and send us an example of your

[3]https://microbit.org/en/2018-11-02-bitio-minecraft/

micro:bit courses." The only possibility to modify content on the site to translate already existing content[4].

Figure 3.4: Provided categories one can browse on the official BBC micro:bit homepage. Links to projects, lessons, and a variety of technologies and subjects.

Inspire Ideas There are a large amount of links to different websites showing how they used micro bit. They even provide a whole page for ideas[5], titeled 'Lessons, projects and more to inspire', of how to use micro:bit.

The site does not seem to have functionality for saving or recording scenarios/ projects or activities for later. As mentioned previously there does not appear to be a way to modify or create new content on the platform.

Communication The only form for communication provided is the possibility to create a support ticket with micro:bit. There are no forum or other visible tools that allow users to communicate, collaborate or share content.

Support Educators The site appears to be a collection of links. There is not a large amount of content the user can interact with on it. Therefore it is hard to say if it is intuitive to use. There are no functionality that supports the educators in creating or modifying content for their context.

There is a guide on how to get started with micro bit as a teacher[6]. It is titled "Micro:bit resources for teachers" and links to research on using micro:bit for teaching programming, as well as some lessons on getting started that provide different activities. Some of these are also links to the curriculum in British schools.

Available It is easy to locate information on micro:bit, and their main website is one of the first to come up in a search. It supports a variety of different languages and allows users to translate their content to even more languages. There is also a large amount of content without the page being slow.

There does not seem to be an offline or download option for their activities. There is an online editor for programming the micro:bit, that would require Internet access to use.

[4] `https://microbit.org/translate/`
[5] `https://microbit.org/ideas/`
[6] `https://microbit.org/teach/`

3.6 Comparison of Platforms

3.6.1 Results

The grading used in Table 3.1 is based on the list of criteria from Section 3.1 and are defined as,

- Good - Meets all of the criteria for this point
- Little - Meets the criteria to some degree, more than one but not all of the criteria
- None - Meets very few or none of the criteria

	Accessible	**Interact**	**Inspire ideas**	**Communi -cation**	**Support**	**Available**
UMI-sci-ed	Little	Good	Good	Good	Little	Little
Lær Kidsa Koding	Good	Little	Good	Little	Little	Good
BBC micro:bit	Little	Little	Good	None	Little	Good

Table 3.1: Comparison of the three platforms and how they meet the criteria derived from the Higher-Order Requirements presented in Section 2.2

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3.7 Discussion

All the platforms score Good on inspiring ideas, which shows that they have the possibility of browsing and view a large number of activities or scenarios. They also score high in the Available-category, as most of the resources are easy to locate if one knows what you are looking for. They got an average score on how accessible and easy to interact with the systems are. There is much information available on different sites, but how easy it is to find and understand varies. Interaction scores are not as high since both LKK and Micro:bit had no available way for users to add or modify content directly. UMI-Sci-Ed scored best when it comes to interaction since it allows users to create content directly on the platform. The lowest scored were in the Communication and Supporting Educators categories. BBC micro:bit did not offer any way for users to communicate.

The varying degree of communication, especially on the individual scenarios shows that this has not been prioritized. UMI-Sci-Ed did score well in this point, with a lot of different ways to communicate. It could be looked into if this allows for more efficient communication or if any of the communication gets lost because of the different options.

The communication in forums was something both LKK and UMI-Sci-Ed shared. This could be a good solution. LKK mostly used their forum for broadcasting or for internal conversations for the members of the organization.

None of the platforms had a full score on supporting educators. This might be reflected by how none of the tools are primarily aimed towards educators. However, both LKK and micro:bit have parts of their content aimed directly towards teachers and educators. This focus was more so on how to use the tools and go through already existing scenarios with students, but I could not find something on how to structure new activities.

3.8 Conclusion

Some of the analyzed platforms had content that focuses specifically on teachers and the process of getting them started with teaching programming. This can be seen as a way to offer support for non-tech experts who wish to teach programming. However, only one of the platforms, UMI-sci-ed, focused on the creation of these scenarios and activities. The other two suggested using tools that were not implemented in their platforms to contribute activities to their platforms.

The weakest categories were the support of educator and communication. It shows that there is a need for a tool that can support educators in the creation process of creating activities and scenarios. Especially a tool that should make it possible to create activities, and that is intuitive to learn and easy to use. A solution that allows users to create activities with support could be an extension to at least LKK and micro:bit. It could possibly be extended to more than just these two online platforms for learning resources.

Chapter 4

State of the Art

4.1 Tinkering and Problem-Based Learning

Tinkering involves letting students explore tools to develop their knowledge of how things work. Rather than having a step-by-step guide, a problem is introduced, and the students use tinkering and their creativity to solve the problem. Resnick and Rosenbaum describe tinkering as playful, experimental, and iterative, where the tinkerers readjust their goals, explore paths and imagine new possible solutions [21]. Another term used for a similar approach is Problem-Based Learning (PBL). The goal of the method is for students to achieve a deeper understanding of a subject and develop their higher-order thinking skills[12]. The project-based learning process consists of three phases; planning, implementation, and assessment [13]. An example of tinkering could be to make students get a piece of cardboard to float over a fan [10]. They have to build their hypothesis of how the world works through how the different cardboard contraptions they perform over the fan. They might have to go through iterations of their products, making them change their idea of how to make it work.

In technology, there is a focus on learning the process, and not only on learning how to use specific tools as technology is constantly evolving [18]. One method that can be used in the technology is learning how to problem solve. It is, therefore, not only important to teach students how to use tools, but also to focus on how they can continue to use the skill of solving new problems that they can acquire through tinkering. If tinkering implementation is done well students can develop a skill set to come up with creative solutions, in new situations or to new problems that can be valuable [21]. The educators of programming can, therefore, focus on not teaching how to use the available tools, but also the learning process.

4.2 Guidelines for Tinkering

There exist different guidelines on how to do tinkering inside and outside of the classroom. Bevan et al. focus on tinkering as serious play and have created guidelines for teachers who want to introduce it in their schools [10], while Mader and Dertien provide a method for using tinkering in academic teaching [19]. Resnick and Rosenbaum share some key lessons that they have learned from their experiences with designing for tinkerability [21]. Bevan et al. present a set of guidelines that are ”create an environment for making, interleave fabrication and tinkering, provide multiple pathways, show that making is a common practice and don’t equate making with the tools alone.” While Mader and Dertien present a method for setting up a tinkering project to teach design in academic teaching, the list of what should be present in a project are ”Playground, toolbox, seed, maturity, goal, feedback and group context [19].” These have some overlapping points and some different perspectives.

Both guidelines focus on how to create a creative environment. Mader and Dertien uses the word playground to express how the creative environment is not just a physical space but also a mental space[19]. To achieve this the educators need to think about the layout of the room, available tools and language that is used in the environment. Students should be able to leave the projects they are working on in the space to minimize the effort to continue [10]. The environment should also allow students with the possibility to collaborate. This can be addressed by the layout of the space and by adding tools that help with collaboration and reflection such as a drawing canvas [19]. Having other example projects on display can also be helpful when creating an environment for making [10, 21]. This shows that the space have to be created in a way that gets the students mentally and physically able to tinker.

Having tools available can be important, but is not necessarily the most crucial aspect of a project. Mader and Dertien’s method uses the expression the toolbox. It explains how through exploring tools the tinkerers can build up their own ”personal toolbox”, which reflects their knowledge of tools. These can be any material that can be used to solve the problem, such as hardware, programming languages and physical materials such as pen and paper[19]. They note how ”making a toolset smaller stimulates students to explore the potential of the components in more depth.” Resnick and Rosenbaum present three principles on how to create a good toolkit for tinkerability. The principles are ”immediate feedback, fluid experimentation, and open exploration [21].” These can be useful for an educator to know what to look for in a tool when designing a project. Bevan et al. point out how it is important to ”not equate the making with tools alone”[10]. It is important to note that the tool alone do not make the project. Tinkering is a process led by people and it is important that the students have an educator who is able to help them. Therefore tools are important and the students should learn how to use them, but the tools are not the only thing the student’s use to solve a problem.

Getting started and capturing the students interest can be challenging [12]. What Mader and Dertien describe as the motivation or starting point they call ’the seed’. The seed should be something that inspire tinkering. What can be the seed is depends on the students and their experiences. The seed or motivation can also be used by the educator to help students become better tinkerers. One of the five points in Bevan et al. guidelines describes how to show students that ”making is a common practice” by connecting the process of making to the students daily life and interests. ”Provide multiple pathways”, is also one of the points and means that there is not just one right solution to a problem [10]. There are different ways to define tasks to achieve this. The educator might define the final result, but the students have to figure out how to solve the problem. Or the students can define their own problems, this technique is usually reserved for more skilled tinkerers [19]. There are different ways to get the students motivated and to keep their interest. It can be achieved through getting them to become better tinkerers and providing them with the opportunity to create their own solutions.

Educators might have to teach students new material before or while running a tinkering activity, and facilitate the students while running an activity. It is suggested to do this through ”interleaving tinkering with fabrication”. Fabrication is described as following a recipe to create a product. This means introducing students to new ideas by starting with easier, combination of fabrication and tinkering tasks [10]. This supports the educator as they can plan how to introduce new material to their students. The educator can use feedback to help the students without solving their problems. The participants should be able to fail and solve their own problems but the educator can help them when starting out or during the process by stimulation [19]. The educator also have to think about the group context, meaning what groups work well when working. Competition can be a good driver, by having students want to create better ideas than other students or making them want to create something that stand out [19].

The guidelines provide an overview of what the authors suggest should be present when doing a tinkering activity. These are aspects that can help an educator when they define and pan activities with tinkering. While both agree on the importance of having a space that promotes tinkering, Bevan et al. focuses more on how to make tinkering work while Mader and Dertien focuses on what should be present when setting up a project for tinkering.

4.3 Methods, Techniques and Challenges

Problem-Based Learning (PBL) is a similar approach where students learn through solving a real-world problem. This approach is different from the traditional classroom, as it is student-centered, and students are required to collaborate to be able to define and solve the problem [17]. The main focus of PBL is on improving the students higher-order thinking skills and promote understanding of the subject[12]. PBL focuses on self-directed learning, and having an educator who is an excellent facilitator is an essential part of making the PBL approach successful. PBL is inherently motivating, as it challenges the students [17].

Some of the techniques or methods to support educators while running a tinkering or PBL activity overlap with what is addressed in the guidelines. Some of the identified main reasons for PBL not being popular are how much time it might take up, the challenge with having the students take active roles and knowing how to evaluate the students [12].

4.3.1 While Starting Out

When first introducing Problem-Based Learning into a classroom context there are different approaches that can be applied. One approach is to have students and educators who have limited experience with Problem-Based projects get familiar with the concept. This can be done through introducing smaller PBL challenges, called 'post-holes' [12]. Post-holes are shorter projects, and helps get students ready for larger scale projects. It can also be done as a 'mini-workshop' where students are introduced to the relevant topic and tools for the future project [11]. This works as a starting point, and introduces PBL in a smaller scale than if educators were to jump straight into a large project.

There is also a need for creating a culture for a collaborative classroom [12]. To achieve this educators can make the whole class reflect together [12]. Charlton and Avramides used this method in school and had a brainstorming session with students [11]. After an initial mini-workshop the students were to come up with ideas for a larger project, then they had to decide on three of these as a group. Having the students collaborate as a group can help foster a collaborative classroom.

Educators might want to get familiar with Problem-Based Learning before starting a project. One way to learn is from watching others who have experience with the process conduct a project. It is also possible for them to run their own smaller projects before starting bigger ones so they can build up their experience, as described earlier. Some educators also have the opportunity to work in groups, letting them develop a community which they discuss with and get support from[12]. These groups can also be interdisciplinary, consisting of both educators and experts in other fields[14]. There are different ways to gain experience with PBL.

4.3.2 Facilitate and Provide Opportunity to Reflect

When doing PBL or Tinkering the roles of educators and students are different form your traditional classroom. Having to adjust to new roles can be challenging and time consuming[13]. One suggestion for making the transition easier for both parts is to provide scripts, also called 'rituals', on how to do activities during the different stages of a project[12]. Scripts on how to design, film or edit a video, or other subjects. It is important to note that creating these scripts and other resources can be time consuming for the educators[13]. This requires educators to anticipate what material the students might need during their projects, and is part of why planning for PBL can be a time consuming process.

It is important to keep in mind that PBL brings changes to the way students work as well as the educator. They need support and guidance to not become frustrated. Frustrated or unmotivated students can result in frustrated educators. One way to support students is through scaffolding. Scaffolding is described to "refer to the tools, strategies, or guides that enable learners to reach higher levels of understanding and performance than would be possible without them [12]." It is divided into two categories of dynamic or static support. Respective examples being to ask students questions, give feedback and support students, and to provide students with pre-defined material.

Support as well as having the students reflect is an important exercise, and can help them develop their higher-order thinking skills. Asking questions, challenging ideas or suggesting hypothesis to investigate makes the students think. It is an alternative to giving them the answers. This supports students in continuing their exploration and could help keep them enganged [12, 21].

4.3.3 Keeping Students Interest

A challenge can be to get students interested in the project. To get them involved educators can work to ”recruit” them early in the process of defining the problem [12]. One way to create a problem can be to let the students students tinker and then base a task on the results from this tinkering session. It is also possible to show students examples of previous projects [12]. These could be projects created by previous students. A collection of diverse examples can help the students with thinking differently [21]. Involving students in the problem definition process can help with getting them interested.

Keeping the students attention is another possible challenge. One way to do this is to provide student participants with the opportunity to articulate and elaborate on what they are doing and learning [12]. Recording this for later and having checkpoints, can also help teachers when grading the students work and help keep them on track. This recorded data can also be used to get the students to reflect on what they are learning. Reflection is therefore a tool that can be used to keep the students attention on the project.

Tinkering can be a playful, but also serious exercise, and one should not forget play as a means to engage students [21]. Resnick and Rosenbaum does as mentioned in Section 4.1 describe playfulness when designing as a way to constantly explore, experiment and try new things. One of LKK’s five principles is that ”Coding club is fun!”, noting how LKK’s events are outside of school and not every students is prepared to learn a lot in every meeting[4]. So there should also be an opening to have some fun while tinkering.

4.3.4 Planning

It is important to keep the size of a project in mind. It could be argued that a narrower and constrained problem is easier for the students to handle. Using a method of keeping the problem and requirements visible and reminding the students of them can also help keep students on track and stop them from deviating too far from the problem [12]. Others suggest setting themes and not challenges[21] as these could let students explore. It should be possible for participants to explore the problem, but it should be specific enough for the projects created as a solution to the problems to have something shared.

Teachers participating in a study where they were using PBL reflected over some of the challenges they met [13]. They mentioned how it is important not to underestimate time and that they had to be prepared and wanted to find relevant materials to use before starting the project. They also reflected on how to group students and knowing how to do so. What students should be put together, and should groups of students who are struggling get a different problem form everyone else? These are questions be helpful for educators who want to use PBL or tinkering to reflect on.

Chapter 5

Conceptual Model

In this chapter, the process of defining a tinkering activity is identified and presented in a conceptual model. Firstly the sub-processes of the defining an activity will be discussed. Then this data will be presented in the form of a conceptual model. This model can give support to educators by providing the process of defining a tinkering activity, also by providing some suggested methods on how to plan the sub-processes of creating a tinkering activity.

5.1 Purpose

The purpose of creating the conceptual model is to provide an overview of the identified process of defining a tinkering activity. This was done to support for educators who want to define activities, as the analysis of platforms in Chapter 3 showed that there was a lack of support educators in the definition of activities.

Through collecting data on how to create an activity, educators can get an insight into how to structure tinkering activates successfully. Also, by defining a model that illustrates the process at a conceptual level, it can be used to define requirements for a platform, so the needed functionality to support educators could be created.

5.2 Procedure

The conceptual model is based on the analyzed interviews in Section 2.3, the results of the analysis in Chapter 3, and the literature review in Chapter 4. Stakeholders were identified based on this knowledge, and two scenarios were designed. These scenarios were created to help guide the design process of the conceptual model. Then the gathered information was categorized, and the data from different sources was firstly analyzed alone as the different data focused on different parts of the process. Meaning that the data from the interviews and literature review was analyzed separately before it was collected and categorized together. These categories were used to identify the sub-processes of creating a tinkering activity and used to define the conceptual model.

The conceptual model was firstly created based on the initially identified categories. The model was re-visited as the categories were taking form, and was improved iteratively as the data was analyzed and changed to clarify the sub-processes. Some additional content to the model was also created, to explain the three first sub-processes as these had identifiable methods for supporting educators in these processes.

5.2.1 Stakeholders

The stakeholders are educators of programming. Educators job vary, and there are teachers both in or outside of school. Some of the educators outside of school are volunteers with some or no formal teacher training, while others might be experts in different fields but might not have teacher training. Their goal to teach programming to children are the same, but while some educators have to meet criteria such as learning goals, others can have free reins. Because of this, this model will not be designed to fit a specific context but let the educators define their environment.

Educators experience with tinkering and teaching in general vary. They also have different experiences with technology and what tools and environments are available for them. This conceptual model is not aimed directly experts of creating tinkering exercises, but for anyone to be able to define tinkering activities for their context.

5.2.2 Scenarios

The scenarios were created to help illustrate how a finished model can support educators and help guide their design process. The scenarios are before and after scenarios, showing what an educators process could look like before and after the use of a model or ideally platform that supports them in defining activities with tinkering.

The before scenario in Figure 5.1 show unmotivated students and a frustrated educator. The educator knows what tools are available but not how to structure an activity. She creates a step-by-step activity where all the results of the students are identical, and they only learn how to use the tools to create this one product.

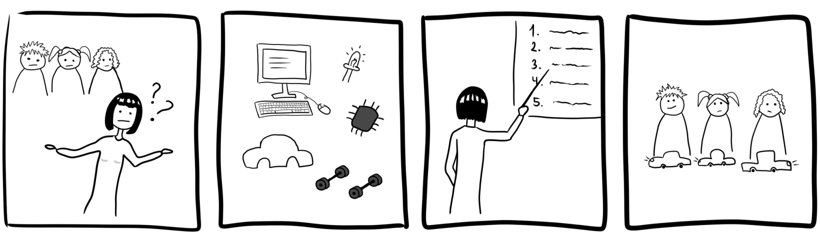

Figure 5.1: Image 1: An educator is unsure what to teach her students **Image 2:** The educator have some available tools. **Image 3:** The educator let's her students go through a step-by-step guide to create a car that have working lights **Image 4:** The student end up with the same results, they are not very happy.

The after scenario in Figure 5.2 shows how the educator has spent time selecting tools and thought about the classroom space. The students are now discussing ideas and using a language that reflects how they have learned to solve problems. The educator has prepared for how to support the students in the process. The products the students have created are no longer all the same, and the educator and students are content.

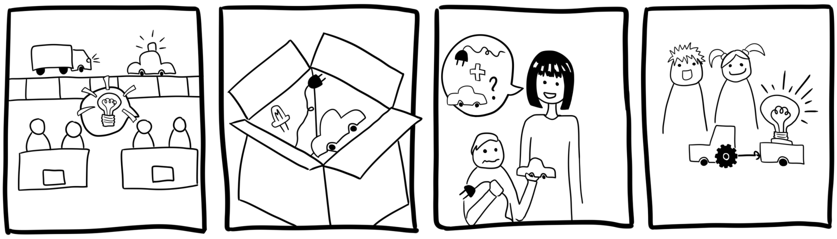

Figure 5.2: Image 1: The educator have re-arranged the classroom and student projects are displayed around the room. The students are discussing ideas. **Image 2:** The available toolbox **Image 3:** A child is stuck with his project, the educator supports him by asking questions **Image 4:** The students end up with creative solutions, they are happy.

5.3 Results

The result in this section come in three parts, firstly there is the identified sub-processes of creating a tinkering activity. Then the conceptual model showing the whole process was created, and lastly additional tables that show three of these sub-processes were constructed.

Before executing an activity in a classroom setting, it has to be planned. When the activity is planned, it needs to be implemented in the classroom setting. Now the educator has to support students, answer and ask questions, and provide ways for them to reflect. In some cases, such as in schools, the students will be evaluated on their work. Running activities in coding clubs or other programming activities however, might not require assessment. Because of the varying need for assessment, the focus of this project will be on the first two steps in the process. These are the initial planning and the planning of the implementation phase.

From Chapter 4, the State-of-the-Art and the analyzed interviews in Section 2.3 some different guidelines and methods that could be used in implementing a tinkering task were explored. From the interviews there was a focus on motivation, providing support for students and educators, and on how to structure activities when implementing them. The guidelines focused on what should be present and focused on when introducing tinkering in the classroom. Some techniques to avoid common challenges were also identified. This information was used to identify ways to support educators by providing them information on how to define a tinkering activity.

5.3.1 Categorization of Sub-Processes

The process of creating a tinkering activity consists of many sub-processes; the ones identified from the data will be discussed in this section. The main process of creating an activity can be, as identified in the literature, divided into two main categories. These categories are what needs to be present when starting to plan an activity and mention techniques to help plan for the implementation of the activity. Before beginning an activity in class, everything should be planned, both how to implement it and strategies of how to facilitate the students in the best way possible. The first things that need to be planned are what needs to be present before starting the project. These are the problem motivation, description and criteria, tools, and environment. The second thing is then to plan for what resources or other help the students might need throughout the implementation of the project. These two categories are both important and should be focused on when defining an activity for the classroom.

First Step of Planning an Activity

The first category is the things that need to be in place to be able to plan the implementation of an activity focusing on tinkering. These are the environment, the tools, and the motivation, as well as the defined problem with description and criteria.

Environment The environment should be created with a focus on collaboration and making. It is a physical and mental space, and the layout and language used in the space have to be considered. The language should focus on the processes of solving problems, collaboration, and using technology. The educator has to think about how to group students and the size of groups since students have different experiences and ways of learning. The educator also has to create the layout and have available tools that allow students to collaborate, such as shared desks or paper to write on. How they can make the student's projects readily available and easy to start back up is also important to consider. The space should also be a source of inspiration and can have previous projects or available tools readily available for the students. It is important to note that the educator's context vary and they have to find what works for them. All of this, the mental and physical space, have to be considered when choosing the environment for the classroom.

Tools An educator has to consider what tools are available and how these can be used. Tools can be any material that lets students solve problems, and can be something physical such as pen and paper or a microcontroller or it can be technology such as a programming language or an algorithm. Educators have to orientate themselves with what materials the schools or organization provide, or what means they have to require new tools. Using toolkits can be a challenge, so choosing the right tools is essential. The educators have to consider which tools their students already know, and what tools the educator want them to use during the process? The educator also has to check out the tools and see if they are useful for the activity they want to define. Some things to look for in a tool is if it shows the students what is happening while they are using the tool, that it is easy to get started with and that it allows for many different solutions. Educators should be able to easily know what tools are available for them and how to use these to get started.

Some suggestions have been found in the literature that could help an educator when deciding on what tools to use. It has been suggested to limit what tools the students can use, as the students can be stimulated from exploring a tool deeper if it is smaller. It is also important that the educator does not let the students believe that only the tools are what is required to solve the project. The students have to develop their understanding of the problem and the educator have to be able to help and guide them. The tool is, therefore, not the only thing that needs to be present to solve the project, and limiting tools can be a strategy to support both educator and students.

Problem Educators have to find a motivating theme or create a problem that motivates the students. They have to come up with a problem description and criteria that help students and makes it easier for educators to know how to facilitate them. There are different ways to define these problems, and it can be challenging for the educators. Some suggestions from the data were collected that could support educators when they create these problems.

Coming up with the problem can be challenging for educators. One suggestion from the literature is to set themes and not specific challenges for the students; these can be considered more open problems and might require students to already be familiar or comfortable with tinkering. There is also a suggestion to narrow the problem description. The problem should allow either different solutions or different ways to the solution, which means that the problem can also be defined by telling the students what they should make. Both methods suggest that there should be something shared between all the students doing the activity, implying that the problem should not be too broad. Lastly, the type of problem an educator can define depends on the students experience with tinkering and their skills with the technology.

There are different suggestions for how educators can define the problem to motivate their students. The educator can use the student's every-day life to motivate their students, as suggested in the interviews and through the literature. The problem can also be created by involving the students in the process, by e.g., letting them come up with challenges from their every-day lives. The educator can keep the students interested in the problem by providing examples of previous projects. Having motivated students support the educator in having a successful experience with tinkering.

Creating criteria can support the educator when they need to support their students. As it tells the students what should be included and the educator can use it as a list to know what parts to facilitate the students on. If a project has to be evaluated, it also supports the educator in evaluating the projects the students deliver. The criteria can be defined to be aligned with the learning goals of a project. Providing different levels to the activity can be another way to support the educator in knowing how to support the students. This can also be achieved by providing the students with checkpoints, letting the educator and student know at what stage they should be at all points of the project. Lastly, it is important for educators not to underestimate how much time the project might take when they are planning it. Creating a structured plan of what should be included and setting time frames for when things should be included can be a method the educators can use when defining their activity.

Planning the Implementation of an Activity

When the groundwork has been planned, the educators should prepare themselves for running the activity. They have to get familiar with how to run a tinkering problem and plan what material they might need to introduce. The educators should also think about how they can facilitate and make their students reflect during the process and how to keep them motivated. This is part of planning the implementation part of an activity.

Getting started When the educators are planning an activity with tinkering, they have to consider if they have run this type of project before and consider if they feel they have sufficient knowledge about the process. If they do not know the process, then the educator should start with a smaller project. This way, the educator is not taking on too much at a time, and can use the opportunity to introduce their students to tinkering as well. The educator needs to learn how to create an environment where their students can collaborate. A way to achieve this could be through having exercises that include the whole class, such as reflections and brainstorming with everyone. To get the educators familiar with the process of running a tinkering activity they can also learn by watching other educators implement an activity with tinkering. Another way for educators to find support is to collaborate with another educator on running an activity. By watching others and having someone to collaborate with the educators can feel supported and become more comfortable with running tinkering activities on their own.

Teaching new material An educator might need to introduce new material to their students. They have to know when and how to do this during a tinkering activity. The educator should have previously planned out what materials could be useful for solving the problem when they designed it. When the need for new material rises, a lesson to introduce this to the students can be run. Another way to teach students new things is to mix step by step guides with tinkering. By first giving the students more manageable tasks to familiarize themselves with the material, and then let them explore new solutions. The educator should also remember to provide the students with feedback by answering questions with questions or by prompting the students instead of solving the problems for them. These are some ways for the educator to prepare for introducing new material to the students, and the educator can choose between these based on what material they need to introduce.

Facilitation The educator has to know what materials the students might need when solving the problems they have defined. When the educator know what the problem is they have to try to think about what materials the students might need when solving these problems by exploring possible solutions to the problem. This requires the educator to spend time on finding and evaluating possible materials that can be used, as it can save them from spending time on this while implementing the activity. This information can be used to create scripts that say how to do things at the different stages of the project. Such as a script on how to create a movie from start to finish. They can also create pre-defined handouts with information on technologies or problems the students might encounter. Another suggested action from the literature was to create a website with links that are relevant for the students. It is important for the educator to spend time before starting the activity to find relevant materials for the educator.

Reflect Helping the students reflect supports the educator in having the students achieve higher order thinking skills. The educator can use different methods to get the students to reflect. They can ask students questions to make them reflect, challenge students assumptions of how things work, or provide a hypothesis that makes the students think. The educator also has to provide their students with some way to reflect. This can be done with a program, in a book or directly on post-it notes. This lets the students reflect and write down their ideas they can be re-visited. This helps the educator with knowing where students are in the process, and it could be used for evaluating students. By supporting the educator to make their students reflect, they can help their students gain a better understanding of the tinkering process and develop their higher-order thinking skills.

Motivation As mentioned when defining the problems the students have to be motivated. To keep the students motivated after the initial project there are some methods the educators can use. They have to remember that tinkering is a playful process and to let the children explore. One way to keep this is to give the students the freedom to chose parts of how they solve the problem. If the problem is to create an animation then they can decide what figure they want to animate. The educator can also use the method mentioned in the Problem-section by recruiting the students in the problem planning phase. The educator also have to consider which students might work well together, and consider how the problem might be adapted to support all the students. Motivation can be achieved through a well formulated and planned activity.

5.3.2 Conceptual Model

The conceptual model is the final result of the iterative process. A conceptual model is a higher order description of how a system should work and should answer the question of how a user will see the system or process in this case. The user will create their idea of how it works and how the structure is. A conceptual model can be seen as the phase between the requirements and design phase.

This conceptual model shows what steps should be included to support an educator in defining a tinkering activity. It shows what processes, from beginning to end, the educator should plan. Tables 5.1, 5.2 and 5.3 show the identified problems and methods or questions they can consider to feel supported in the three first sub-processes of creating an activity. By defining the model for this project it illustrates how the process of creating tinkering activities work at a conceptual level. This can be used to define requirements for a platform, so the needed functionality to support educators can be created.

The symbols in the model in Figure 5.3 is taken from Business Process Modeling Notation (BPMN) [22]. The white circle represents the start of the process, while the black circle represents the end of the process. The boxes with rounded corners represent sub-processes the educator have to go through, and the arrows between them show the direction of the diagram. Diamond boxes with X-symbols represents a yes or no question, and the diamond boxes with a +-symbol represent processes that can happen in parallel.

The representation was used to show the process of creating a tinkering activity from start to end.

The model in Figure 5.3 shows the identified process of creating a learning activity for students from start to end. The educators first have to identify their environment, tools, and motivation and problem, which is described in detail in Section 5.3.3. Then they have to answer if they have done this type of activity before. If the answer to the question is no, they can use the information from the first step to create a smaller activity to introduce tinkering and familiarize the students with the technology. Then, or if the answer to the first question was yes, the problem or motivation for the activity can be defined. From here, the criteria for solving the problem can be defined. This is the first part of defining an activity and can be seen as the first part of the planning phase.

The second phase involves planning for the implementation of a tinkering activity and is represented in the purple box on the lower half of Figure 5.3. Throughout the activity, there will also have to be checkpoints and opportunities for the students to reflect. The educator has to find the material that they think will be useful for the project and plan reflective exercises. When this is done, the educators has to consider what material should be introduced to the students before or during the activity. This can be done through small lessons or exercises where the students can familiarize themselves with using the new tools, depending on the individual material. This is what is included in the second part of planning, the planning for implementation.

5.3.3 Additional Support

Three tables were defined to provide additional support in the first three sub-processes of creating a tinkering activity. The first part of Figure 5.3 shows that creating the environment, finding tools, and finding the motivation for the project can be done in parallel. These three factors still have to be decided before moving on with the planning. These processes were defined from the guidelines and had sufficient methods to be translated into tables representing identified problems and suggested methods that educators can use for these problems.

Creating an environment for tinkering in a class can be challenging for the educator, as they have to step out of the traditional teacher role. They have to focus more on how the students can be supported. Table 5.1 show identified problems and methods or questions that could be used to support the educator when creating the environment for their problem. It is important to remember that the educator's contexts are different, and not everyone might be able to e.g., re-arrange their space or provide the possibility to have old or new projects available. The problems presented in the table are those of creating a classroom for collaboration, and inspiring and motivating students to tinker. By identifying how to solve these problems, educators can be supported in knowing how to create the environment for their context.

Some of the challenges educators face when teaching programming are deciding what tools to use and how to use them. Table 5.2 show categories of identified problems and methods that could help educators when deciding on tools. These problems are finding out what tools are available, deciding the usefulness of a tool, and being able to limit what tools to use for an activity. The identified methods are formulated as points the educator

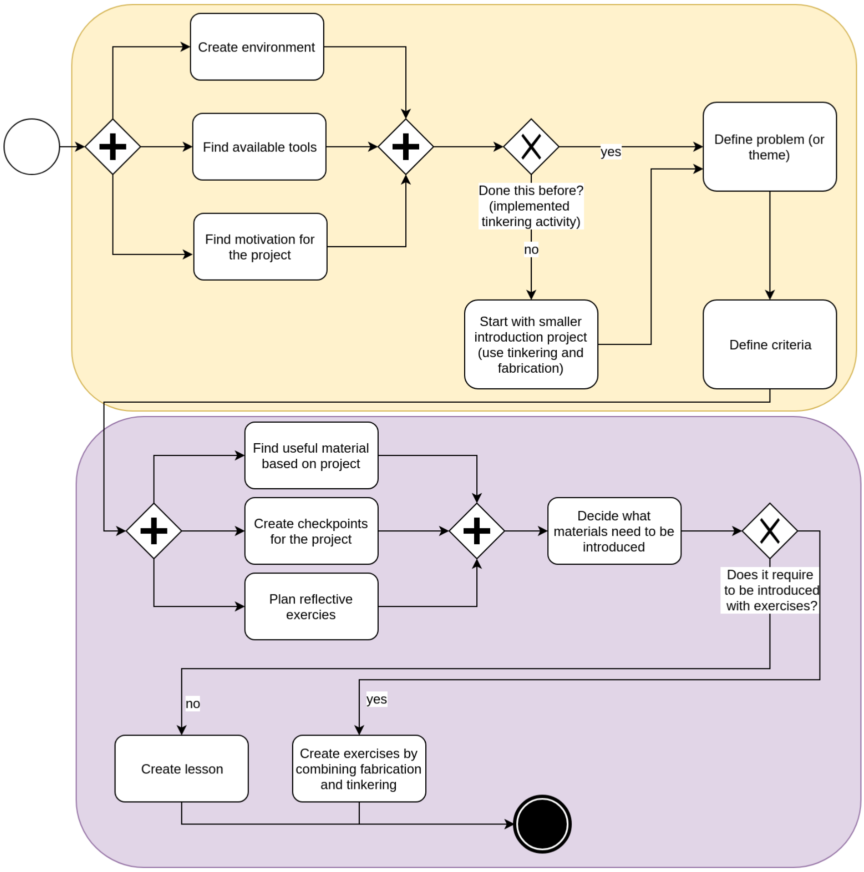

Figure 5.3: The model shows the process of defining a tinkering activity, and is inspired by Business Process Modeling Notation (BPMN) [22]. The educator should be supported through the sub-processes shown in the model. The two large boxes, colored yellow (top) and purple (bottom), represents respectively the processes of planning what to include in the activity and planning for implementation.

Identified problems	Suggested Methods
Promote collaboration	• Consider what about the layout can be changed • Consider how students can be grouped
Provide inspiration and motivation	• Consider how students can get started easily with their projects in the beginning of a lesson • Consider how students can get inspiration from the space • Consider what language should be used in the classroom

Table 5.1: Identified problems and suggested methods for creating an environment for tinkering. The problems are presented on the left side, and the methods that were identified to provide support for the problem are listed on the right-hand side of the table.

can consider, and can providing them with the suggested methods can support them to decide on tools in a structured manner.

The third Table 5.3 focuses on identified problems when it comes to finding the motivation and problem for a tinkering activity. The educator has to create a motivating problem, decide what type of problem they want to run, have the problem provide multiple pathways, and define the criteria for the problem. The identified methods are suggestions that can be used to provide the educators with support when finding the motivation for their setting and defining their problem.

5.4 Discussion

The model is based on data from different sources, so more data could be used to create a more accurate model of the process. It is important to note that these were the identified steps needed to support an educator through the process of defining a tinkering activity. The model should be tested to see if the model represents the process and all the steps in the right order. There might be a need to move around some of the steps or do more of the planning in parallel.

The model is not complex, and more detailed steps would have to be included to ensure full support of educators. One attempt to make it more detailed was by defining extra tables that represent some suggested method that educators could use to feel supported. These selected sub-processes had enough information to have identified challenges and suggested methods on how educators can deal with these challenges. A more detailed model could have been created to include these suggested methods. However, the aim was

Identified problems	Suggested Methods
Finding available tools	• Consider what tools are available to the educator • Consider what means there are to require or learn about new tools
Deciding the usefulness	• Consider if the tool is useful for what you want the students to achieve with it • Consider if the tool easy to get started with, does it provides useful feedback and does it allow the users to create different solutions
Limiting tools	• Consider if it is possible to limit the tools that will be used • Consider if it will be helpful to limit the number of tools

Table 5.2: Identified problems and suggested methods for choosing tools for tinkering. The problems are presented on the left side, and the methods that were identified to provide support for the problem are listed on the right-hand side of the table.

Identified problems	Suggested Methods
Criteria	• Can the criteria reflect the educators learning goals • Reflect on what the students to achieve with this project
Chosing type of problem	• Consider how experienced the students and educator are with tinkering • Decide on what kind of task, setting challenges or finding a theme • Do not underestimate time
Providing multiple pathways	• Consider problems that will get the students individual projects to have something in common • Allow different solutions or different paths to the solution, there is not one right solution
Motivation	• Promote tinkering, remember that it should be an iterative and playful process • Use every-day life for inspiration for motivation for the project • Can also use students for inspiration by including them in the process of finding the motivation • Set up checkpoints for the project

Table 5.3: Identified problems and suggested methods for choosing motivation or defining problem when creating a tinkering activity. The problems are presented on the left side, and the methods that were identified to provide support for the problem are listed on the right-hand side of the table.

to keep the model not too detailed to keep the process of defining a tinkering activity clear. The model could also have been split into two parts, of planning what needs to be included and planning for implementation. With two smaller models, more details could have been added to the model without it becoming complex.

The end result is a simplified process of creating a tinkering activity with supporting tables. By defining this process in a model, this can be a starting point to define requirements. These requirements could be used to provide the needed functionalities for a platform aimed at educators to be able to support educators in the whole process of defining an activity with tinkering from start to end.

Chapter 6

Conclusion

6.1 Summary

This thesis explore how educators can be supported when creating tinkering activities for their context. This was explored because some educators feel the lack of support when teaching programming in school, while other educators have no formal teacher training. To be able to educate their students about technology, it is essential that these educators are supported. They could be supported in many ways, and the need to focus the task was achieved through analysis of existing platforms and collected data. The exploration of what was lacking when supporting educators was done by analyzing platforms that offer some support to educators. This analysis concluded that functionalities that allows users support while creating their own activities were missing from these platforms.

The theme of tinkering was selected based on experiences of the educators that were interviewed for the specializations project [9]. Methods and guidelines with a focus on supporting educators when creating tinkering activities were identified through a new analysis of the data from the interviews, as well as a literature review focusing on guidelines and methods for introducing tinkering.

At last, a Conceptual Model focusing on the process educators need to be supported through when creating tinkering activities was developed based on the gathered data. The model is a simple guide that shows the processes the educator go through to when defining an activity using tinkering. Additional tables that present methods for supporting educators in the first steps while making tinkering activities were developed as a substitute for the model. By defining this model, it illustrates how the process of creating tinkering activities work at a conceptual level. It can be used to define requirements, so the needed functionality to support educators can be created and added to existing platforms.

6.2 Discussion

In this section the answers to the research questions will be discussed. The main research question was **RQ1**: How can educators be supported when defining tinkering activities? To find the answer to this we will firstly look at the answers to the two other research questions.

Beginning with **RQ1.1**, how can guidelines for tinkering in the classroom be used to support educators? Two guidelines focusing specifically on bringing tinkering into a classroom and setting up for tinkering in a classroom was explored in the literature review. These guidelines helped with highlighting what parts of the process should be included and considered when creating tinkering activities. They provided some overlapping information on how to create the environment for making, selecting tools and defining problems even if their focus was different. These ended up providing a foundation for the conceptual model and tables.

The guidelines could be used by educators, which would support them in taking away some of the challenges with finding out what to focus on when creating a tinkering activity. However there were no directions or explanations of what order the steps of the guides should be included in. It would also have been interesting to explore guidelines that were already implemented by educators, and look at the order and steps they took to create a successful tinkering activity. More guidelines or other research would have to be explored to be able to create a better understanding on how to use only the guidelines for creating an tinkering activity.

The guidelines brought an understanding of and focus on:

- How to create an environment that supports tinkering
- What to look for when choosing tools for a project
- Defining motivations and problems
- Introducing new material while using the tinkering approach
- How to facilitate students during project

The next question was **RQ1.2**, what other methods can be used to support educators while defining a tinkering activity? To substitute the information gathered from the guidelines, interviews were analyzed and more literature on tinkering and problem-based learning was explored. This included more strategies that could be used by educators when planning an tinkering activity. The literature and interviews here brought an extra focus on:

- Dividing tasks both into easier and harder problems, or to provide checkpoints during the activity
- Getting familiarized with tinkering or problem-based learning through smaller projects
- More focus on how to make the students reflect
- Identifying different steps in the process of defining an activity

The main research question was **RQ1**: How can educators be supported when defining tinkering activities?

By identifying how educators can define a tinkering activity, more support can be offered to the educators. This means that by collecting knowledge on the process of creating an activity, the educators can be given an insight into how to successfully structure an activity with tinkering. Educators can be supported by being provided guidance in the process of creating a tinkering activity.

This master thesis has contributed a conceptual model that shows the whole process that the educator needs to be supported in. The information gathered to answer the two sub-research questions was used to form this model. It illustrates how the process of creating tinkering activities work at a conceptual level. This means that it can be used to define requirements so that this needed functionality to support educators can be created and added to existing platforms.

6.3 Future Work

There is a need to evaluate the model and use this information to improve it. Especially with regards to how to support educators in each of the steps of the model. An evaluation from experts who have experiences with creating activities would be beneficial.

To be able to implement the model, requirements have to be formed. After this, technologies and design choices would have to be decided on. The main focus of this thesis was to find out what methods could be used to support educators. The next step in the development of a system to support educators could be to focus on technologies that can provide support, by identifying what research has been done on supporting users. Also identifying what needs to be present in order to support an educator through the use of technology. This might be with tutorials, help-functionality, or other solutions, as we know that the educator wants to see the immediate usefulness of something.

The final goal would be to create the implementation of the conceptual model presented in Chapter 5 to support educators in defining an activity and test it on relevant users.

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