Influence of soft materials on student engagement with STEM: 
Combination of technology, programming, and textiles in a maker movement activity
ABSTRACT

While the computer programming becomes a fundamental skill in the last century, it has been globally acknowledged that there is a decline in number of graduates in disciplines of Science, Technology, Engineering and Mathematics (STEM). Many scholars have been addressing this lack of interest and studied student engagement with STEM through variety of engagement programs and activities. In this master thesis as an exploratory qualitative study, technology and programming are blended together in a workshop hosting students of age 12-13 towards the development of their enthusiasm and engagement with STEM. During the activity, students used Makey Makey toolkit and Scratch programming language by application of textiles as soft material to investigate how this combination impact the engagement, and in what ways soft materials influence it. The study results in the light of Flow theory showed that four attributes of attention, motivation, engagement and social interaction pursued in the workshop. Textiles, as a mediator by expanding the flow state boundaries make the activity softer to encourage students being engaged in it, particularly from a gender perspective.

Key words: STEM students, Maker Movement tools, fabric/textile, Flow theory
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List of Abbreviations

LED Light Emitting Diode
DIY Do It Yourself
DIWO Do It With Others
EFT Exploration and Fabrication Technologies
ICT Information and Communication Technology
STEM Science, Technology, Engineering, Mathematics
1 Introduction

The digital society has been developed and became operational since 1990 in Europe and Asia. One decade after termination of digital societies, the notion of smart society evolved. In future, virtual and physical spaces will be closely linked together and the attention will move from exploitation of systems to the evolution of them and designing of society (Ishida, 2017). For that reason, today’s, novel skills and competences become essential for citizenship related to work and life, not only for experts but also for majority of people. It’s our responsibility to explore approaches for providing skills, knowledge, and capability for children to continue affecting the society through technology. The computer programming is an example of those new fundamental skills in the early seventies which was used in educational context as a central pedagogical practice (Papert, 1991 cited in Blikstein, 2013, p.1). Despite this essential need, it has been globally acknowledged that there is a decline in number of graduates in disciplines of Science, Technology, Engineering and Mathematics (STEM). Because of this trend, educational providers have organized variety of student engagement agendas with the aim of student attraction for retaining them in STEM disciplines at all levels (Ross et al, 2017).

In conjunction with digitalization and technology development, new tools and techniques are used to make objects like as 3D printers, laser cutters, programming, e-textiles, and smart textiles. The notion of maker movement is defined as increasing number of people who engage in designing, creating, building, and adjusting objects both physically and digitally. Through this movement, makers share a collective set of values about playing, repairing, learning, and cooperating. An important value to be gained is participating and sharing the approaches of their effort to be openly accessible for other participants (Ball et al., 2017). Looking at educational context, digital fabrication and ‘making’ are constructionist tools for students to create innovative ideas and literacies for making physical artifacts alongside digital ones which simultaneously develop creativity and inventiveness. The constructionist vision signifies a key contemporary approach in educational technology settings (Lee & Fields, 2017).

Today, e-crafting is aligned with maker movement which makes waves across the world by providing more fun and suitability to develop digital lifestyle (Lee & Low, 2017). It has mostly drawn attention to the creation of objects such as robots or drones made by computers, cables, and welding. Gradually this has been moving to use new microcontrollers which crossed the borders with respect to type of materials which are used (Lee & Fields, 2017). In this arena, development of conductive and electronic materials provides an opportunity for collaboration between researchers, engineers, and designers to create the techno-craft and do-it-yourself (DIY) practices in order to combine different disciplines and help the beginners to engage with interdisciplinary technology collaborations (Seymour, 2008). Making electronic and smart textiles are a disruptive area in maker movements (Kafai et al, 2014), brings together many learning advancements, such as picturing, planning, sketching, creating, wiring, coding, monitoring, testing, correcting and team working. In other words, by realization of pupils’ ideas, their senses are stimulated (Reimann & Maday, 2016). While e-textiles have been applied increasingly by users of various backgrounds, the mission ahead for informative scientists is to investigate what learning accomplish with their use (Lee & Fields, 2017).
1.1 Research Background

In the 1980s, the prevailing approach was a movement from industrial to informational society. People started to consider the information as a driving force in the community. This approach shifted to thinking about knowledge-based society in the 1990s where researchers focused on management of knowledge for individuals and organizations. Although both information and knowledge are significant, but according to Resnick (2003, p.1) they are not sufficient. The future success of people as individuals, communities, organizations, and nations depends on their capability of thinking and acting creatively. As he mentioned “The successful societies of the 21st century will be Creative Societies”.

One of the key factors of supporting education in science is to increase students’ interests. It plays an important role in persistence of students during learning. One way to make and support mentioned interest is engaging them in activities to understand the significance of engineering and experiment in their daily routines. In other words, when there is not an appropriate connection between students and science, they generally have negative attitude towards it (Tofel-Grehl et al., 2017).

E-textiles are expanding users’ visions and interests in computing by combining of making, computing, and electric circuit. Kafai et al (2014) defined three central features of e-textiles that create enough interest in computing. First, making transparency in computing and electricity to see the connections more clearly. Second, tangibility of e-textiles which makes an opportunity for sharing experiences and products with friends and community. Third, the specific pedagogical attitude that promotes inspiration as open-ended projects. Basically, by this approach students feel that they are able to make anything they want such as hats, jackets, and backpacks. It supports individual independency in a learning space. Maker practices provide occasions to create interest in science by delivering student-centered context including hands-on crafts and digital fabrication technologies (Blikstein 2013). In particular, working with e-textiles increase the autonomy of students for making while they face challenging problems.

Human, devices, capabilities and resources are gathered together in one location by Makerspaces and FabLabs in order to practice designing and prototyping through a do-it-yourself activity (Blikstein, et al., 2017). They can be used in different contexts including educational institutions. Todays, there are open access tools and kits provided by collective organizations. According to Blikstein (2013, p.1), makerspaces are considered as “the democratization of invention”. Recently, students are taking part in makerspaces in schools, universities, and libraries. Contribution in mentioned spaces enable students to become maker and innovator. At the same time, their interest towards science, technology, engineering, arts, and mathematics (STEAM) will be increased. The topics like as engineering and programming have been introduced to participants which might have not any experience in electronics, coding and technical aspects. Makerspaces also facilitate various pathways to acquire 21th century skills through providing collaborative and iterative tasks by building a learning atmosphere (Papert, 1980 cited in Blikstein, et al., 2017, p.150). They use a series of toolkits and equipment with the aim of learning through creating.

Current technology assessment tools related to effectiveness of digital fabrication settings can be considered as a threat for the future of teaching and learning approaches. It may convince educators to make their activities aligned to insufficient standards. Therefore, it is important to clarify what creates evidence of knowledge in those settings. Blikstein et al. (2017) developed
an evaluation designed especially for Exploration and Fabrication Technologies (EFT). These technologies are aligned both with fabrication such as activities for invention, designing and building, and those aligned with exploration which are activities concerning expression, tinkering, educating, and innovation. In order to evaluate the students’ understanding of EFT and their competences with EFT, they designed two measures as confidence and performance based on their previous research on implemented fabrication settings in educational context.

The theories of Constructionism & Constructivism as stated by Hamir et al (2015, cited in Roffey et al, 2016, p.8) are “theory of learning based on experience and observation. Through experience, and reflecting on these experiences, individuals construct their knowledge and understanding of the world”. In constructionist educational environment, a central focus is on development of technological intuition in students to promote the learning through designing and sharing in collaborative setting (Papert, 1996, cited in Roffey et al, 2016, p.8).

1.2 The research problem

Nowadays the digital technology has disrupted the way people conduct their works in every sector. Educational systems are getting updated everywhere to meet opportunities and challenges of digitalized society (Heintz et al, 2017). In education settings, while the widespread acceptance of digital fabrication is being increased in last years, less has been explored about the effectiveness of these technologies with the aim of supporting the real future learning skills (Blikstein et al, 2017). In recent years, the programming and computer science are considered as important learning skills for everybody. Accordingly, most countries have revised their school curriculum to introduce these subjects in basic education. Although digital fabrication and making labs are conventional in Sweden, there is a few researches to assess the level of students engagement and efficiency of such practices for better encouragement of students towards learning digital skills which are necessary in future (Lisa, 2018).

It is also a need to investigate the students interest for sufficient engagement with digital technology through maker movement as a learning methodology specifically from a gender perspective for girls and women (Bocconi et al, 2018). Here the combination of digital technologies with soft materials like as textiles is providing ideas’ creation and innovation for pupils engagement with new technologies. Since the digital tools have been used by students are made of hard components, they will enjoy fabric ones that are soft, gentle and comfortable when holding or working with them (Buechley, 2008).

1.3 Previous studies that have addressed the problem

The Seymour Papert (1991, cited in Blikstein, 2013, p.1) quoted that, if it was possible for a 16th century teacher to be presented in todays’ schools, he or she may have not any problem related to teaching tasks in a class. According to historical evidences it is no need for him to be more accurate. The multiplication and division taught in 14th century had similar algorithms in comparison with what are used today. For instance, current mathematics classes are similar to courses run by Ghaligai in 1519. Such courses are based on memorization and measures including multiplication, algorithms usage, partition, portions, and the rule of three (Swetz & Smith, 1987, cited in Blikstein, 2013, p.1).

Blanca and Brandt (2010) stated that only the people will succeed in new social situation who have enough up to dated knowledge and skills. Skills competency in 21th century provides capability to hang onto learning and regulating for people. Low-paid and low-skill jobs are the
consequences of insufficient skills which are achieved in education. They argued that there is need for a new model of education in the US to meet the required skills of 21st century. Eisenberg who was the pioneer of application of digital fabrication in education concerned that by making available the fabrication tools for students of all ages, there is a critical necessity to study the ways of developing these technologies in order to avoid using them only as a push-button device (Eisenberg, 2013). Digital fabrication practices regularly support skills of building, in which participants endure multiple cycles of thinking, designing, frustration and enthusiasm. Those experiences are not conventional in school practices, but digital fabrication increase competences according to STEM skills (Iversen et al, 2015).

Student involvement can be assumed as a cognitive practice, active contribution and emotional engagement in a learning process where ICT engagement explicitly maps connection and involvement of students with digital technologies (Howard & Yang, 2016). Lee & Low (2017) in Malaysia investigated the interest of students towards STEM by crafting in a project called Science2Action and illustrated that it makes them feeling pride, happy, amazement as well as developing creativity. They also reflected that technology and craft can fit well together.

Blikstein et al. (2017) stated that the attitude towards personal creativity in combination with the position of learners at the center of digital fabrication facilities make a dilemma for valuation. It is difficult to assess a practice which is open-ended and creative. The traditional evaluation of science and technology does not cover the specific kinds of learning that students are engaged in. On the other hand, it does not reflect to what extent the digital fabrication tools impact the competency development of students. The instructors who relied on applying the fabrication settings in schools found that, it provides transformative capabilities for participants (Blikstein & Worsley, 2016 cited in Blikstein et al., 2017, p.151). However, they cannot determine the learning outcomes related to pedagogical functionality of these settings. Therefore, particular instruments are required to count users’ confidence when they use the fabrication technologies, in comparison with the current instruments which are deployed in ICT. By spreading the digital fabrication settings in schools, it is a need for appropriate models to track technology literacy and learning progresses associated with these settings. Blikstein et al. (2017) proposed an instrument to capture the correlation of students’ confidence and technology and their technical efficiency in fabrication settings.

Asunda and Mativo (2016) reported in their conceptual framework of educational teaching technology, that in STEM it is still focused on science and mathematics with less attention to technology and engineering. Although in some cases there are technology and engineering considerations, they are not satisfied in content standards and student efficiency objectives. Their paper introduced an integrated STEM conceptual framework which consider problem-based learning and pragmatism to be used by teachers. The theoretical buildings of their framework are based on systems thinking, constructivism, situated learning theory, and goal orientation theory.

1.4 The significance of the study

The gap between skills which are learned at schools, and skills which are needed in ICT, design, and work areas is considered as a reason which makes it difficult for graduated students to find job. On the other hand, today’s technologies used in education and teaching do not applicably meet 21st century needed skills (Kahn et al, 2018). In current setting of schools, new technologies are basically supporting old methods of teaching and learning (Ecraft2learn, 2018). Therefore, there is a need to move towards combination of technology and making
movements to provide knowledge and skills which students need. Digital fabrication and making skills, if combined with appropriate learning techniques, can deliver necessary competencies such as creativity, innovation, critical thinking, group working in addition to skills for problem solving. Today, the importance of empowering young people with digital-centered skills like as programming and computer science takes into considerations by governments alongside with scientific approaches. For example, Gustav Fridolin (The local, 2017), the education minister of Sweden emphasized on the fact that, while Sweden is a superior nation in the high-tech industry, but instead of leaning on this reputation, it is an important necessity for Swedish children to be exposed to technology since the early age. According to his idea, these skills are not only helpful for students who are getting in programming jobs, but also useful for everybody at every place. Since many careers need competency in computer and digital skills in future, he mentioned that:

"This means Sweden is taking the kind of approach we should have. Sweden should be a country where every kid in school is prepared for working life, and knowledge of programming needs to start early"

Since 1955, the new curriculum has been followed in Swedish schooling system in which the crafts were a compulsory syllabus subject rather than an optional topic. In 1962, by merging the crafts with single subjects like as woodwork, metal and textile, a practical and aesthetic change took place in that program (Arvidsson, 1989). In line with other countries, Sweden remarked digital competence, programming and computer science as interdisciplinary skills to be integrated with other subjects like as mathematics, technology, and social studies. In the 1980s, basic science of computer was taught in grades 7–9 as a part of mathematics subject. Accordingly, national outlines were initiated to make students ready for living in a computer-based world. Later in the 1990s, attention was moved from computer science to digital literacy where students were learning with computers, rather than learning about computers. The main change in curriculum began after 2012, while education providers highlighted an essential need to encounter flowing job requirements. Since programming and software experts are the most prevalent jobs in Sweden and internationally, they debated that the programming should be taught in schools integrated with current subjects. Others argued that the general training of any kind of job should be offered to students in the spirit of computational thinking to enhance digital competency. Finally in March 2017 the new curriculum became mandatory, in which the programming has to be a part of existing subjects from fall 2018. The logic behind this integrated approach are (Heintz et al, 2017):

- Avoiding a large scale curriculum with new subjects
- Allowing students to experience programming in different subjects
- Leading to computational thinking as a framework for students to solve complex problems with the help of computers

According to my background in textile engineering, it is feasible to use textiles as a facilitator to provide the combination of these subjects with programming and computer science. For instance by developing e-textiles and smart textiles, a broad range of functionality will be provided. Smart textiles are referred to products like as fibers, threads, and woven, knitted or non-woven fabrics that can interact with the user and environment as well. E-textiles which are made of conjunction of textiles and electronics can be used in wide spectrum of applications as a flexible and enjoyable electronic product towards increasing social wellbeing (Stoppa & Chiolerio, 2014). In making activities, e-textiles are kind of hybrid movement for connection of digital and material in both authentic and aesthetic ways. It helps varied groups of youth to
identify different disciplines through linking computing with hands-on DIY craft (Kafai et al, 2014).

1.5 The statement of the purpose

In this paper, I will investigate the application of self-made textile substances as a learning process for students of age 12-13 towards the development of their enthusiasm and engagement with science, technology, engineering and mathematics (STEM) curriculum. It takes place aligned with the project of ecraft2learn which is “an integrated learning ecosystem that provides tools, support and training for innovative learning, contributing to opening learning towards innovation through a craft- and project-based pedagogical approach in STEAM education” (ecraft2learn, 2018). The aim is to help development of skills relevant to digital technology which are needed in 21st century for answering challenges related to it and to study the level of student engagement with today’s technology regarding themes of understanding and interests.

1.6 Research question

RQ- How combination of digital technology and programming with soft materials impact student engagement with STEM in a maker movement activity?

1.7 Thesis organization

This thesis is organized according to following disposition as shown in figure 1:

Chapter 1. Introduction, is including an opening introduction following by research background, problem, deficiencies in previous studies, and research question to provide the significance of study as well as statement of purpose.

Chapter 2. Literature review presents main theoretical aspects grounded in this study. It is organized in six sections around STEM, digital fabrication, learning by making, e-textiles, students HCI, and flow theory explanation.

Chapter 3. Methods, introduces the methodology which has been used in the study. The practice design, data collection method, and workshop participants are explained afterwards. Since children are involved in this study, the ethical consideration is emphasized in final part of this chapter.

Chapter 4. Empirical findings, gives the data gathered empirically based on data collection methods. It contains four sections including students answers, interview, observation, and video recordings with pictures which have been taken either from workshop or videos.

Chapter 5. Discussion, presents discussions about the empirical findings of this study based on theoretical framework and literature review described in earlier chapters. The research question is answered in this chapter.

Chapter 6. Conclusion, provides the conclusion of the study followed by the further research suggestions.
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**Figure 1- Thesis organization**

- **Thesis**
  Influence of soft materials on student engagement with STEM

- **Chapter 1**
  Introduction

- **Chapter 2**
  Literature Review

- **Chapter 3**
  Methods

- **Chapter 4**
  Empirical findings

- **Chapter 5**
  Discussion

- **Chapter 6**
  Conclusion & Future works
2 Literature review

In this section, I review the literature related to research objectives in order to give information about the fundamental key words and concepts. First, I describe the definition of STEM discipline and the importance of paying attention to it. Second, the notion of learning by making is reviewed by explanation of DIY and maker movement phenomenon and its application in educational contexts. Third, I overview the digital fabrication and e-textiles as two efficient developments of maker movement activities, followed by a review of children and technology interaction. Lastly, I present the flow theory from scholar literature to use it in the discussion section.

2.1 STEM

Science, Technology, Engineering, and Mathematics (STEM) indicates a symbiotic connection between four interlaced fields. The notion of STEAM covers four mentioned areas plus Art. In STEM, learners achieve a fundamental comprehension of the content. It empowers advanced skills of thinking to find out solutions which are incorporated a diversity of disciplines. Moreover, it provides the information which are essential to solve challenging problems. Thus, the STEM discipline offers a broad collection of metacognitive and content-based educational support (Basham & Marino, 2013).

In last decades an agreement has emerged about the necessity of improvement of K–12 students in STEM. Many considerations about the STEM quality are about the challenges that societies face in an rapidly interconnected competitive world. The overall idea is that, progress in STEM education help to overcome those challenges in two ways. Firstly, it will continuously keep the students equipped to pursue occupations in different technical and scientific areas. Secondly, it would promote the literacy level of scientific and technological knowledge in people. So, it enables new generation to enter effectively in the worldwide marketplace, support themselves and improve their general life quality (Fulton & Britton, 2011).

In 2011, Fulton & Britton investigated the effects of professional learning communities on future of US. Their findings illustrated that the competitiveness capability of community in a global innovation economy depends on mastery of youth and students in science, technology, engineering, and mathematics (STEM). It motivates the students for becoming ready in order to invent and reinvent the work in future. Problem solving, knowledge development, and non-stop skill acquirement are the results of this involvement (Fulton & Britton, 2011).

Looking at two components of ‘S’ and ‘M’ as science and mathematics, they play a long historical role in K–12 education. Both fields have standards, courses, variety of reference books and other training resources. Each student in school has probably a minimum level of skill in them when finishing the high school. The basis of STEM instruction lies in engineering, which many instructors did not pay enough attention to it. Katehi and Feder (2009) stated that, of the four letters in the STEM, the “E” is not understood and utilized properly. A small number of people consider the engineering as a K–12 issue, and a few number of teachers are involved in engineering. In addition, a small number of schools offer engineering ideas and practices to students. In other words, engineering can be consider as a missing part in STEM.

Notifying the (T) as technology in STEM education, several researches have been done since 1986 to be continued in 2000 by releasing the technology literacy standards (ITEEA, 2017).
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Their works were first focused on developing critical thinking to solve practical matters by exposing students to design practices and engineering. Besides, the National Assessment of Educational Progress (NAEP) expanded their goals towards technology and engineering literacy rather than only technology literacy. Their framework consists of three distinct sections of technology and engineering activities including technology and society; information and communication technology (ICT); and design plus system. The third area covers fabrication settings because it is including engineering and design and technical problem solving. According to this framework it is a need to evaluate the students’ capability to look at the technology from an engineering system perspective. Leaders and members of the American Industrial Arts Association (AIAA) in 1980s emphasized on the need for technology education as an important part of STEM. The goal was stated as, all Americans should become technologically literate specially students which should be career-ready. In 1996, the technology was placed at the center of US national agenda on educational improvement. The International Technology and Engineering Educators Association (ITEEA) highlighted that students should be exposed to engineering and design settings to learn critical thinking through engagement with tools, systems, and spaces (ITEEA, 1996 cited in Blikstein, et al., 2017, p.152).

2.2 Digital Fabrication

Digital fabrication is a new digital revolution. It has the same perceptions of the earlier digitization of communication and calculation, but now emphasis on what is programmed in the physical space instead of virtual word. It facilitates people to design and make tangible products on demand, whenever and wherever they need (Gershenfeld, 2012). Digital fabrication affect how individuals design, harvest, and interact with artifacts. By giving a closer link and quicker iteration among the digital and physical objects, fabrication assists novel associations between objects and interfaces. It also simplifies new design techniques for prototyping of interfaces, allowing advanced relationship between designers and users (Mellis et al, 2013).

Fabrication rooted in constructivist concepts for creating the learning spaces since 1916 in Dewey’s innovative works about democracy and education. He defined the social impact of education for citizenship preparation in a progressive democratic evolution. Then, he studied the linkage between learning and social communication practices which raises a flourishing democratic citizenship (Dewey, 2004). Learners’ behaviors of performance and thinking is developing over time, and it can be supported by fabrication accomplishments and toolkits in order to support these evolving steps. In this framework, self-directed learning occurs with the assistance of others and the avability of expressive tools. Mediated learning occurs when learners engage in rich conversations with others and with artifacts as well. The value of fabrication settings is embedded in constructionism concept by emphasis on the significance of creating artifacts in a supportive community context (Papert, 1991 cited in Blikstein, et al., 2017).

The growing reputation of digital fabrication activities, for education and exploration, creates an important position in providing the skills that students must acquire. Lewis, Petrina, and Hill (1998 cited in Blikstein, et al., 2017, p.150) specified that these skills improve the creativity for solving the problems from the technological perspective. Variety of practices like as laser cutting, 3D printing, molding and soldering, and making circuits help students to improve their capabilities related to problem solving. By considering the technical issues and identifying the appropriate scientific and design approach, the students are facilitated to design
implemented solutions in several iterations.

2.3 Learning by making

2.3.1 Do-It-Yourself

People are motivated to fix their tools, construct objects, stitch fabrics, build chairs, make meals and code computational programs. They like to devote time on repairing their own things. They also enjoy sharing experiences and skills with others to develop social communications at the same time. These activities are rooted in do-it-yourself (DIY) tradition. Basically, DIY includes a collection of creative practices in which the current materials are used, repurposed, and modified by people in order to produce something. These methods are occasionally organized and shared so that other people will be able to replicate, re-interpret or develop them. A DIY workspace will deliver an opportunity for participants to collaborate around projects and share acquired knowledge (Buechley et al., 2009).

Nowadays, many online communities like as ‘DIY.org’ and ‘Instructables.com’ provide a lot of opportunities for young people to do DIY projects, view other projects, connect with them, and to record the work. For instance, Instructables has piecemeal guidelines to make a range of projects, accompanied by uploaded pictures and video. Additionally, makers are able to ask and answer the questions of other users through community forums. Another example is ‘DIY.org’, which is one of the growing communities of DIY portals specially for children. It offers directions and rewards badges for fruitfully carrying out a sequence of projects (Peppler & Bender, 2013).

2.3.2 The maker movement

Maker movement is referred to rising amount of people who are involved in the creative construction of objects by modern digital technologies in their everyday life. It helps people to discover physical and digital opportunities and to share these experiences and products with a broader community (Halverson & Sheridan, 2014; Cohen et al., 2017). The maker movement signifies a growing interest in building artefacts with playful and also beneficial ends. It pursued by hobby makers, tinkerers, technicians and engineers, hackers, and artists as well (Martin, 2015). A variety of things can be made in maker movement activities such as robotics, electronics, digital fabrication, wood, metal, and textile crafts. Regardless of this broad range, the movement provides a unified promise to foster exploration and to inspire ideas. Two features of cross-generational and cross-cultural contribution can be followed accordingly. It means that a wide range of participants can take part in activities. There are including parents with capability of fixing, grandparents who know sewing and crocheting, and others with expertise in home woodwork. In fact, maker spaces are places for individuals with a range of skills. So, they share their passions and connect them to historical and cultural traditions which are important to local families (Peppler & Bender, 2013).

Although the origins of the maker movement are not clear yet, scholars agree that the theoretical foundation about learning by making, or constructionism, was provided by Seymour Papert in 1980 (Ball et al., 2017; Halverson et al., 2014). While the basic practices of making roots in crafts and amusements like as woodworking, stitching, and electronics, the notion of maker movement outlined since 2005 by make magazine. By emergence of online networks and digital fabrication tools, these pursuits have been expanded more easily to share, evaluate, and compare (Martin, 2015).
Whereas this movement was settled in out-of-school settings with adults as participants, it is rising attention among researchers to bring it into schools. In this way, they make occasions for students to being engaged in such activities, specially, in STEM learning. The maker movement in educational context has been developed because of conceptual and technological needs in schools. Project-based learning, making things by computing kits, constructivism, programming languages for beginners, and low-cost digital fabrication tools are examples of mentioned needs (Blikstein, 2018). It is a global culture transmission for physical and interactive learning on the basis of designing by using innovative technologies (Blikstein, 2013). Peppler and Bender (2013, p.23) highlighted that “The maker movement is an innovative way to reimagine education”. In this context, if components of the maker movement be deployed appropriately, an educational transformation will be accomplished in variety of disciplines (Cohen et al., 2017).

As the result of this widespread interest, a number of science and technology providers like as Tinkering Studio in San Francisco, Ingenuity Lab in Berkeley, and Maker Space at New York Hall of Science were developed accordingly (Martin, 2015). It is a growing approach with widespread attention in the world and US. For instance, the white house of the US is hold National Week of Making every year, and the international Maker exhibitions have visited by more than one million attendees (Bers et al, 2018). In fact, the learners experiment their own projects through making which are conducted by influential ideas and expressive tools. It nurture simultaneously different competences such as inspiration and creativity as well as frustration and breakthrough (Blikstein, 2013; Bers et al, 2018). Today, making activities expanded from maker community societies, exhibitions, and labs to school laboratories and classrooms (Kafai et al, 2014). According to Blikstein (2018), main reasons of this widespread acceptance are including: (1) social acceptance of the designing for advanced and dynamic education, (2) countries tendency to build an economy on the basis of innovation, (3) promoting of the mindshare and demand of coding and making, (4) high reduction in costs for digital fabrication as well as physical and digital computing technologies, and (5) expansion of new capable, simple tools for pupils, and more demanding academic research in field of education in makerspaces.

Maker movement involves students in do-it-yourself (DIY) and do-it-with-others (DIWO) practices to develop unique objects. It encounters a high potential for inspiring students into making rather than only using current technologies. By creating maker movement innovative environments, participants are engaging with process of collecting and sharing resources, knowledge and information. Particularly in STEM disciplines, it provides opportunity to learn, question, doubt, and solve the real problems (Karppinen et al, 2017). While “making” covers different activities such as woodworking and even cooking, it mostly support application of hardware and software computational tools and make them affordable and reachable for public (Kafai et al, 2014). In makerspace labs, students are engaged in practices like as table-top rollercoaster, building light-up textiles and sculptures, or building a pinball device from recyclable things. These learning involvements, which influence the process of collaborative designing would be more significant for learners who have not access to typical facilities of STEM education. The educational makerspaces are considered as project-based instructive activities together with informal means of looking, valuing, understanding, and performing. They create both individual and group working in a participatory culture. It this way, the identity of participants, either as individuals or as community members, will be developed to engage with their surrounding world (Bers et al, 2018).
2.4 E-textiles

In e-textiles, the conductive materials such as thread, yarn, and fabrics are intertwined with copper, silver, or other conductive fibers. They are replacing wire and producing new type of wearable computing. Although the components manufactured for e-textiles look different from those in robotics, they have almost same foundational infrastructure. Many companies have developed simple friendly toolkits appropriate for using in computing learning, such as LilyPad Arduino, fabrikit, and Aniomagic (Peppler, 2013). They have been used to promote different features of physical computing at educational environments including in-school, out-of-school, and higher educational settings. Electronic textiles are an increasingly widespread topic in maker movement which play an important role in do-it-yourself activities. They provide new experiences for learning by challenging existing conventions of educational environments. According to Kafai & et al (2014, p.532), e-textiles can be considered “as one disruptive area of making” with three characteristics of technology transparency, integration of aesthetics, and diversifying computing fields. It is also an opportunity and challenge to break the obstacles of computing. Making e-textiles became an surprising and fertile setting in which students can learn and develop the engineering and computing fields. A growing trend in using e-textiles is grounded in capability of physical and digital combination. In e-textiles both electronics and computing are using in combination with the soft textile substances like as conductive fabrics. Moreover, digitalization of these products gives them a new form of materiality which make them generative (Yoo, 2012).

In 2007, LilyPad Arduino toolkit released to market and was used to build interactive apparels, sculptures, and textile-based interactive objects. This toolkit contains a number of sewable electronic components such as microcontroller; a collection of lights, speakers, switches, and sensors; and a reel of conductive thread (Buechley, 2008). As shown in figure 2, the toolkit is sewed on the fabric with the thread, which delivers both the physical and electrical connections. The microcontroller is programmed by either the an open source Arduino, or a visual language called Modkit. It enables users to configure it graphically and to make programs including computational basic concepts (Peppler, 2013).

![Figure 2 - With conductive thread, a user sews connections between a Lily-](image-url)
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By using open hardware boards like as LilyPad Arduino, a durable collaboration is being made between the person and her/his creation favorite. It is very favored by female users because of its round shape and easy sewable feature. Looking at this characteristics, more women and girls are involving in STEM fields specifically the computing area which seems to be more open to men and boys (Buechley, 2008).

Most of computer courses in schools planned to involve students in using applications either simple software or complicated data simulation, rather than motivating students to produce them. So, such pedagogical courses only support understanding of software and computing, while the inner part will be still hidden like as black boxes. Dissimilarly, the e-textiles enable students to experiment the messiness side of technology. By using them, functionality behind the interface of tools will be learned. They comprise activities such as detaching, designing and assembling to understand the relation between components. Actually, by involving participants in e-textiles designing, instructors can inspire students agency towards problem solving and creating with tools. This is in contrast with the prevailing trend that is considering students as technology consumer, rather than technology producer. The questions such as what should be made, how to make it, and in which ways it works, are important features of working with e-textiles in design process (Kafai et al, 2014).

An additional value of applying e-textiles in DIY electronics is that they give visions of production of technology and designing. It helps to nurture basics of technological fields through visual and aural learning (Peppler et al, 2014). According to Peppler (2013, p.41), when e-textiles are applied in STEM, they “allow for open-ended exploration, a high degree of personal expression, and aesthetically compelling possibilities”. However, there are not enough documentation about influence of e-textiles on ability of thinking about computation (Lee & Fields, 2017).

2.5 Children, Technology, Human-computer Interaction

Children needs, interests, hates, and likes are different from adults. It is a fact that the technology designers sometimes consider children as “short adults”, instead of a specific population with dissimilar culture, norms, values, and complexities. For this reason, technology developers often ask parents and teachers about their children needs, rather than involving children themselves. This can be due to traditionally dependence of children on their parents from basic needs to advanced experiences. The dominant view based on this tradition makes young people “all-learning” adolescent in front of “all-knowing” adult. These points of view make it problematic for young students to express their preferences about the technology they like to use at school or home (Druin, 1999). Since new technologies are very critical to children’s lives, it is need to ensure that young people are considered as learners and explorers instead of only users. According to Druin (1999, p.4), in order to avoid making children only users of technology, the role of them in technology designing process should be defined. He suggested a framework on the basis of the children’s role in four levels: user, tester, informant, and design partner.

As user, children are engaged with development process of technology by using it. Researchers examine this role to recognize the impact of existing technologies on children in order to change the design of future technologies. In the level of tester, not-released technology prototypes will be tested by children. Then they express their comments and experiences to be used for enhancing the pre-released technology. Children play the role of informant when they contribute in the process of design at different stages by offering inputs and drawing sketches.
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and low-tech prototypes. At this level, they are asked to suggest input and feedback. And lastly, in design partner role, children are partners in technology designing through a full experience. They, as stakeholders, contribute to this process in appropriate ways for themselves (Druin, 1999).

2.6 Flow theory

Flow is a state when one deeply immerses in an activity under control but without reflective self-consciousness. On the flow state a high focus takes place by individuals which hinder other thoughts or disruptions to be interfered (Sahid et al, 2016). The flow concept is developed not only in academic disciplines, but also in wider spheres. For instance, Nakamura, J. and Csikszentmihalyi, M. (2009, p.195) looked at life from the flow perspective as “a good life is characterized by complete absorption in what one does”. According to Shernoff et al (2003), individuals absorb in an activity by an inherently enjoyable sense with the optimal capacity. Examples are athletes and artists when they concentrate on their works. In this status, even though no specific goal is grasped, people perceive their activity very satisfying and fruitful for its own sake. The flow concept was presented for the first time by Csikszentmihalyi (1990 cited in Sahid et al, 2016, p.3) who denoted a topmost experience of involvement in an practice.

The important building blocks of flow experience which enhance students learning and motivation are including: (1) explicit objectives; (2) instant feedback to one’s activities; (3) individual skills related to given tasks; (4) merging of act and consciousness; (5) focus on the activity at hand; (6) feeling of prospective control with no fear of failure; (7) sense of no self-consciousness; (8) a distorted sense of time; and (9) understanding which becomes self-induced (Csikszentmihalyi, 1997). Chen et al & Shin (1999; 2006 cited in Sahid et al, 2016, p.3) categorized these characteristics in three classifications: “flow antecedents, flow experience and flow effects”. Whereas the flow antecedent includes items of clear objectives, instant feedback, and adequate skills; the flow experience consists of three items of act and consciousness, activity concentration, and sense of control; and finally the rest of items containing sense of no self-consciousness, a distorted sense of time, and self-induced understanding are defining as flow effects.

![Figure 3 - Flow states (Sahid et al,2016,p.3)](image)

The flow state is also portrayed with two involved variables which are skill and challenge. According to Nakamura, J. and Csikszentmihalyi, M. (2009, p.196), challenge is reflected as
action opportunities, and skill is considered as action capabilities. As shown in figure 3, confrontation of skill and complexity of challenge demonstrates three conditions of anxiety, boredom, and optimal flow to be occurred.

The condition of optimal flow takes place when the level of challenge is at the same level of person’s skill to meet those challenges. However, this balance is fragile when each variable exceeds the other. As a result, it turns to other conditions. These states are anxiety and boredom. The sense of anxiety and restlessness occurs when the person’s skill is less than the level of challenge. In this condition the participant becomes vigilant and eventually anxious. On the other hand, the condition of boredom or relaxation is achieved when the skill is higher than the challenge complexity. In such condition, student feels relaxation which turns later to boredom.

In addition to these three states, there is also another state, so called apathy, in which the skill and challenge are both in a low level. Since the dynamic of these three situations plays an essential role in students engagement with an activity, it is important to balance two variables of students’ skill and challenge in the same level. So, it retains participants in optimal flow condition to reach the maximum engagement. In order to avoid the experience of anxiety and boredom, the level of challenge should be decreased and the skill level should be increased respectively. While students seek to overcome higher challenges, they should develop the level of their skill. Consequently, the state of flow invokes a growing attitude, in which the capacities of engaged participants is developed (Shernoff et al, 2003; Sahid et al, 2016; Nakamura, J. & Csikszentmihalyi, M., 2009).

2.6.1 Flow and Student Engagement

Student engagement with an activity is studied by Fredricks et al (2004 cited in Jeffery, 2017, p.2) in three dimensions. First, behavioral engagement which is related to academic and social contribution; second, emotional engagement which focuses on students’ interactions with other participants such as classmates, and teachers; and third, cognitive engagement that considers students’ enthusiasm to solve the challenging tasks and look for additional knowledge which are in accordance with the flow theory variables. Nonetheless some researchers like as Anderson and colleagues (2004 cited in Jeffery, 2017, p.18) added psychological engagement to these classifications. Pupils’ engagement is influenced by different factors such as phenomenological and instructional aspects as well as teacher, school, and individual issues (Shernoff et al, 2003).

If three aspects of concentration, interest and enjoyment be experienced in an activity, the cognitive engagement will be achieve (Csikszentmihalyi, 1997 cited in Shernoff et al, 2003, p.3). Concentration is a deep focus and rich absorption on an action which raises learning experiences in educational settings and develops talent capacity. Interest in doing a task is another essential factor which leads to continues motivation and following learning. Based on sense of interest, pupils grab opportunities to acquire, read, cooperate, and get feedback in order to increase curiosity for harder tasks. Enjoyment is another important aspect which provides the sense of satisfaction and accomplishment in intellectually challenging activities. Feelings of enjoyment in an event is usually accompanied by talent and creativity development (Shernoff et al, 2003).

In order to see pupils’ engagement in the light of flow concept, different methods has been deployed including semi structured interview and experience sampling method (ESM). Although it is possible to review the dimensions of flow by using questionnaires, in real-life settings, the interview method provides a general measurement of flow experience. It is rooted
in the fact that the flow concept arises from the qualitative attitude to investigate individual’s feeling when they engage in an activity (Csikszentmihalyi, 2000 cited in Nakamura, J. & Csikszentmihalyi, M. 2009, p.198). Many studies showed a link between flow and students engagement. When flow experience occurs the person will be encouraged to engaged more in the activity due to experimental rewards it supplements. Consequently, people become motivated to continue and return to activity and develop their skills and abilities repetitively.
3 Methods

3.1 Research methodology
The dominant approach in this study is the qualitative method. However, in order to have a clear understanding for data analysis I partly applied quantitative approach only to demonstrate numeric comparison between collected data. A generic definition of a qualitative research is described as a method which places the observer in the world in order to make that visible and study the natural phenomena with natural science. In qualitative research the world is turned into the couple of representations through notes, conversations, photos, and recordings. Qualitative data can be collected from variety of sources such as observation, interviews and questionnaires, documents, and texts as well. Scholars try to make sense of, or understand a subject through the meanings people assign to it (Myers, 1997; Denzin & Lincoln, 2008).

A qualitative research can be positivist, interpretive or critical based on underlying epistemology of study (Orlikowski & Baroudi, 1991 cited in Myers, 1997, p.4). Positivists, normally suppose that the reality is not dependent on researcher as well as his/her instruments. The reality is given objectively and only need to describe through measurable properties. Generally, a theory is tested in positivist paradigm to provide a better understanding of a phenomenon (Myers, 1997). According to Kaplan and Maxwell (1994, cited in Klein & Myers, 1999, p.69), a research can be considered as interpretive if it is supposed that the understanding of reality is achieved through social structures like as language, common meanings, perceptions, documents, tools, and artifacts. In interpretive paradigm, it is not assumed any predefine dependent or independent variables, rather it centers on the complexity of people who make sense when the circumstances arises. It is directed by collection of beliefs and feelings of researcher about the matter as a guidance for its studying. Therefore, researchers organize a wide range of interconnected interpretive practices in order to get a better understanding of the phenomenon at hand (Denzin & Lincoln, 2008). In critical paradigm, it is assumed that social reality is historically shaped and reshaped by people. However, the researchers emphasize on the existing contradictions and conflicts to remove the causes of them (Myers, 1997).

The research paradigm which I used in this study is an interpretivist approach. It is due to nature of research, that is by conducting a workshop as an exploratory project to understand and investigate how student are engaged with STEM when soft materials are positioned. In fact, I as researcher am located at the center of this activity to interpret pupil’s engagement by using the collected data.

3.2 Practice design
The workshop was conducted in laboratory of faculty of technology, Linnaeus University. In order to design the workshop, I and other university participants got together 3 weeks before holding the co-design activity. The goal of this meeting was discussing and making decision about following aspects in three categories:

a) Learning procedure:
- Which parts of STEM learning to be focused on.
- The activities to be done during the session.
- The digital toolkit to be used by students (Makey Makey, LilyPad Arduino, …)
- The programming language
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- To decide about level of difficulty
- How to combine the soft material with digital and electric circuitry and programming

b) Practical organization:

- Time schedule
- Selecting the theme of hand crafting
- Group specifications such as number of students per group, gender composition
- The design and layout of the learning lab space
- Co-design requirements

c) Ethical considerations:

- Follow the school regulations and review ethical considerations related to children
- Preparing letter of consent to be sent to parents and teachers
- Determining the authorities related to ethical issues for further consulting
- Deciding on recording movies and taking photos

3.3 Participants

Participants were 60 students of grade 6 (Age: 12-13) who were divided in four groups and attended two days in workshop. They were local Swedish as well as non-Swedish students with different native mother tongues, however they could mostly speak Swedish. In addition four teachers accompanied them from their school. Other participants from the university were including three lecturers from department of physics and electrical engineering and faculty of technology, and two researchers from department of informatics.

3.4 Data collection method

Data collection was organized mainly by observation of activities which accomplished during the workshop. A semi-structured interview also provided more data to be gathered. However, considering the limitations like as the age of students and their spoken language, it was decided to ask students to write their ideas and responses on paper. According to Walsham (2006) a practical matter in interview of field research is the language and it is obviously better to conduct the interview with the local language. However, since only two students were able to fluently speak in English, I decided to do it with alternative method.

In order to conduct that, the open-ended questions had been written on the white board and we asked students to write their answers in group. In this way, they had time to think about the themes and present their ideas while they were convenient. It was in accordance with Walsham (2006) idea that the quality of interview in interpretive approach in terms of honesty of answer is depending on interviewee to feel relax. In addition, it is easy to review the written answers later by researcher to analysis them again, and direct quotes can be easily picked up from the transcripts. Another advantage of following this manner was that they were not obliged to give responses. So, one group of students left the paper blank with no answer. However, there is a key disadvantage about conducting this form of non-verbal interview, in which researcher does not use the verbal tactics as social skills (Walsham, 2006). Those questions were written on the board in Swedish language. The questions were designed to cover main objectives of my thesis. However after first day of workshop, the questions were a bit modified in order to make them easier to answer. In addition, two cameras were adjusted
to record the whole session from two focused groups randomly. The preliminary consent of adults and guardians regarding with taking photos and recording movies have been taken in advance.

### 3.5 Workshop setting

The workshop started at 9 o’clock with an introduction session for both students and teachers to explain the workshop program as well as the schedule. Twenty six students including twelve boys and fourteen girls were participants of first activity. Since the overall objective of the meeting was engaging students with STEM concepts, they were divided in two groups. In the morning, it was highlighting mathematic topics for one group and technology topic for the other one. In the afternoon, they were swapped to cover all the topics. Since mathematics workshop was beyond my thesis objectives, I just was concentrating on technology aspects. Then four groups of students were shaped to start the activity. The groups structured were as following. This division structure were designed to consider the gender factor simultaneously and its impact on engagement behavior during co-design activity.

- **Group No. 1:** Three girls
- **Group No. 2:** Two boys, One girl
- **Group No. 3:** Two boys, One girl
- **Group No. 4:** Three boys

The workshop began by introducing the chosen theme and toolkit to be used for connecting the handicraft, electronics, and programming. The selected theme was Angrybirds to be designed by fabrics. As illustrated in figure 4 which has been taken at workshop, fabric is then connected to Makey Makey toolkit by applying LEDs and making sounds through Scratch programming. In order to motivate the students to get involved in activity a simple practice had been showed by using a carrot as conductive material to be screamed when someone cut it. Afterwards, the students were invited to do it themselves as a simple programming practice.

![Figure 4 - Co-design theme and toolkit (Makey Makey)](image.jpg)

Following tools and materials were prepared in each station for every group in three categories:
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- Textiles: Fabrics in different sizes and colors, scissor, ruler, colorful markers, glue gun and hot glue, adhesive tape, pins and paper clips, buttons
- Electronics components: aluminum foil, cables, connector wires, alligator clip, and LEDs
- Makey Makey toolkit and required accessories including USB cable
- Programming: computer, keyboard, mouse, Scratch programming language

Students were asked to participate in DIY practice according to following activities:

- Selecting the favorite shape and making it by using the colorful fabrics, scissor, glue
- Making circuits with wires, clips, LEDs, and Makey Makey to be connecting to computer
- Experiencing Scratch programming for making sounds and lights on fabrics

After co-design completion each group of students exhibited and presented their effort and results for other students. In order to gather data, written questions were read for students and they asked to response to questions according to their experience and feelings during the activity. The whole practice lasted for two hours. Makey Makey toolkit and Scratch programming language are introduced in the following.

3.5.1 Makey Makey

In past years, variety of game design platforms has been grown dramatically. The reason behind this grow is to raise computational thinking, to create inspiration for programming learning, and to enhance technological fluency. These open source Tangible Interface Construction kits (TICK) are developed with the aim of lowering the barrier against computational hardware engagement, electricity, and programming. This category includes low cost robotics toolkits like as the Lego Mindstorms, Tern, and Arduino. The MaKey MaKey has been built along with this tradition in particular for students in middle school level. It helps young and amateur designers to make tangible interfaces, and spread game designing in the physical domain. One advantage of MaKey MaKey is that it does not need any driver, any specific software, and no need to know knowledge of programming (Davis et al., 2013).

Makey Makey toolkit (Figure 5) is an academic and artistic device which was designed by two students of MIT Media Lab and is using by thousands of inventors every day. The toolkit is specifically suitable for educational settings where students can design and combine the tangible things with the coding tasks on the computer. The conductive objects can be positioned as input devices for a computer. The users with no coding knowledge are able to use it and experiment the coding skills. The Makey Makey designers believe that by using this device the Maker Movement goes beyond the robots, 3D printing, or STEM, because it provides an opportunity to foster the interest of students in order to become familiar with hardware engineering (Makey Makey, 2018). It helps users to build nature-based interfaces which is well-matched with all software, and it does not need to program or any electronics assembling. It can be used by variety of audiences, from beginners to experts in order to support their ideation.
Considering the technical aspects, Makey Makey implements the Human Interface Device (HID) protocol in which keyboard and mouse actions will be send to computer while there is no need to install drivers or software. Any software which is running on the computer can be controlled by a tangible user interface through ordinary objects connections. Some specific characteristics of Makey Makey which makes it easy to use are including (Collective & Shaw, 2012, p.368):

- Quick start for beginners: it is easy to design a working interface in which the digital output is controlled by a physical input in less than a minute.
- Working with any software: well-matched to any present computer program. The inputs are received the keyboard as well as mouse.
- Nature-based interfaces: allows making the interfaces including natural materials, like as plants, flowers, fruit, soil, water, or the human body. The circuit will be closed when connect to human body, or variety of natural and edible materials like as plant and fruit.
- Programming not required: enables creation of an interface without any computer program coding.
- Soldering not required: it is not need to assemble or solder complex electronics components on a circuit board.

3.5.2 Scratch programming language

Scratch is a graphical programming language for making interactive, media-rich tasks. People are able to create many projects in a visual environment such as animated stories and games, reports, online news display, and many entertainment projects like as greeting cards, music, and videos. The projects which are created by Scratch are including both media and scripts (Maloney et al., 2010). The so-called sprites are 2D colorful objects which can be controlled to move across the background named stage. Images and sounds are inputted through using a built-in paint tool and by using a sound recorder. The creations can be shared with other users in the online community. Scratch helps young generation to think creatively, reason analytically, and act collaboratively. Considering the essential skills of the 21st century like as the capability of coding computer programs, the Scratch provides the ability of solving problems, designing practices, and connecting ideas (Scratch, 2018).
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Bearing in mind the difficulty of early programming languages they were not embraced teens interests and experiences. So, designing of Scratch was inspired from the wishes and interests of people at the age of eight to sixteen. In Scratch programming there is less emphasis on instructions in comparison with other languages, instead it motivates beginners to learn by exploration and sharing. An appropriate programming language for young people should be simple to get started, having capabilities to make advanced projects, and supports different types of tasks for people with different levels of experience. In Scratch, these triple aspects are renowned as “low-floor/high-ceiling/wide-walls” (Resnick et al, 2009, p.63).

Scratch is constructed on the basis of three core principles. The first design principle is the concept of tinkering which develops by mixing the animations, graphics, and photos with sounds and music. It is on the basis of putting together the command blocks with varied colors. In figure 6, I designed a simple combination of blocks. It is bringing in mind the same feeling of Lego bricks. Hereby children examine by tinkering with the blocks, snapping and combining them together in different arrangements to explore what occurs afterwards. The idea of being meaningful is second design principle of Scratch which focuses on criteria of diversity and personalization. When people do personally meaningful projects, they learn and enjoy more because it is coupled with their interest. By simplifying of different types of inputs to be imported like as images, sounds, and music, it is possible to engage in programming personally to motivate the user. The third design principle is social aspect of Scratch which is ability to develop, support, collaborate, and evaluate other’s project through its website. Once a task is sharing in website, it provides opportunity for other users to comment, vote, and download it in order to revise or build their own projects. It inspires young people to start programming and display their projects in front of many audiences which allows them to get feedback about their projects and learn from the other programs as well. In this way, people with no former experience of programming will enjoy understanding of a simple programming language (Resnick et al, 2009; Maloney et al., 2010).

![Figure 6- Scratch script blocks](image)

Originally, the Scratch was used only in informal learning environments like as community settings, after-school activities, labs, museums, and libraries, but gradually it has been used by students and teachers at schools. Although the software and website was officially launched in 2007, its usage initiated in 2003. This free application is available in almost 40 languages using by more than 150 countries (Scratch, 2018).

3.6 Reliability and validity

Reliability and validity are normally applied to quantitative research and it should be reconsidered when are used in a qualitative research. Yonge & Stewin (1988) considered these terms as indices of measurement for accuracy, consistency equivalence. However, they believe
that the nature of qualitative research makes it difficult to measure the reliability. Therefore, it is no relevance between reliability, validity and qualitative research. This is due to narrative data and process of involving researcher in the study. Since, the validity of a qualitative research highly depends on reliability of data which is gathered, it is important to understand the meaning of reliability and validity.

Reliability: The idea of using the term ‘Reliability’ in qualitative research is testing the quality of study. A worthy qualitative research provides understanding of a situation which is enigmatic or confusing. Looking at different meaning of quality in qualitative and quantitative researches, makes the concept of reliability misleading in a qualitative research (Stenbacka, 2001, cited in Golafshani 2003, p.601). According to Lincoln & Guba, (1985, cited in Golafshani 2003, p.601) terms Credibility, Neutrality, Dependability, and Transferability can be used in qualitative research. However, the term ‘dependability’ is more corresponded to the notion of reliability. It is important to examine the trustworthiness in order to ensure the reliability in qualitative approach (Seale, 1999 cited in Golafshani 2003, p.601). researchers such as Lincoln and Guba (1985, cited in Golafshani 2003, p.601) and Patton (2001, cited in Golafshani 2003, p.601) stated that reliability is the result of validity in a qualitative study and its demonstration is adequate.

Validity: In qualitative studies the notion of validity is labelled by many scholars in a variety of terms such as trustworthiness, quality, and rigor (Davies & Dodd, 2002; Lincoln & Guba, 1985; Mishler, 2000; Seale, 1999; Stenbacka, 2001, cited in Golafshani 2003, p.602). Also, it is developed by many researchers according to their perception. Even though some researchers have debated that validity is not applicable in a qualitative research, they have accepted the lack of qualification or measurement for their research. It is initiated particularly in interpretivist paradigm where there is a concern about the validity of research. In fact, the notion of discovering truth or trustworthiness has been done by measuring the reliability and validity which establish the confidence in results (Mishler, 2000; Lincoln & Guba, 1985 cited in Golafshani 2003, p.602).

Using appropriate research methods is critical while children are participants of a study. When the research is including children, the validity and reliability are more difficult to obtain. While provoking children’s visions, it is problematic to believe in children’s accounts of their involvements. Normally it is assumed that they cannot differentiate between reality and fantasy (Punch, 2002). Young students may reflect untruth responses to researchers for a number of reasons rooted in nature of childhood. For example, they might express things they think is in accordance with researcher favorites; and they try to make positive impressions (Ennew, 1994; Gersch, 1996; Richman, 1993 cited in Punch, 2002, p.325). Even though some students responses may not be true, since they look at the world from their perspective the validity of data in qualitative research relies on children’s own validity.

Considering all above mentioned, in order to ensure the validity and reliability in this thesis, several data collection methods have been used. Since students spend their daily time at school, they probably like visual and written techniques in which they have competences (James et al., 1998 cited in Punch, 2002, p.329). Therefore, I combined photography and video recording as visual method, and students responses as a written method. In this way they answer to questions while they feel more comfortable with no pressure. In other words, the interaction is between the children and paper rather than children and researcher. At the same time a large amount of data is collected. In addition, these data can be used later by other researchers if they wish.
3.7 Ethical Consideration

Involving children in a research study is naturally sensitive from the ethical standpoint. The rules and guidelines depicted by UNICEF concerning Ethical Research Involving Children (ERIC) encompasses all social, cultural and methodological researches which are involving young people. Thereby, involving children means any study in which children are either directly or indirectly take part for the sake of collecting, investigating and reporting data as well as information (UNICEF, 2013). Since children’s ability to evaluate risks and predict the consequences are not developed yet, it is normally problematic to take satisfactory consent from them. It is because of the fact that they may simply be impressed by others and situations. In other words, children have less authority and they mostly spend their time in settings which are already planned for them by adults and teachers. Therefore, working with young students is perceived more difficult than working with adults. Hence, the ethical issues when children are participating in a research need more attention considering their powerlessness and vulnerability (Matthew, 1998). In this study, I pursued the ethical consideration in three phases. I label them as following: pre ethical considerations, in-practice ethical issues, and post ethical considerations.

Pre-ethical considerations are requirements I considered before conducting the workshop and interview. The main issue was preparing the consent letter and sending it to school in order to be read and signed by teachers, parents, and students (see Appendix A). The letter starts with introducing the researcher and the aim of study. Then, the permission for recording video and taking photo is highlighted. Other issues like as confidentiality matters, anonymous considerations, and participants right to take part in practice are emphasized respectively. In order to meet all ethical necessities, these issues reviewed in a meeting conducted couple of weeks prior to workshop with other participants. Similar consent letter (see Appendix B) was signed by interviewee before conducting interview.

In-practice ethical issues is referred to ethics and principles which are important during holding the workshop with students. A number of important issues which are considered in this study are in accordance with what Matthew (1998) noted as the ethics of working with children. Firstly, the students have the right to know why they are involving in research and reasons of their involvement have to be clear. Therefore, the objectives of the workshop was explained for them at the beginning of meeting. It was pursued later by introducing other participants such as teachers, researchers, and facilitators. The length of the workshop and total time to accomplish activities were clarified afterwards. Secondly, it is important to arrange for a comfortable setting. Since the context in which students are involving plays an important role in making mutual communication, the groups were formed with maximum three members. A tables was located in front of each group enabling them to move and share their experiences with other groups. All equipment were also placed in every station to make the setting as comfortable as possible.

Postethical considerations in my research is mainly referred to content of my final report. Student and teachers’ names are protected and imaginary names are used instead of real names. Although the consent letter has been previously accepted by all participants’ parents, but in order to respect children’s anonymous right, all photos I used in my thesis including the student are blurred. Moreover, for pictures which are used in report the permission has been obtained from article author.
4 Empirical Findings

4.1 The summary of students responses

In a survey at the end of workshop, students explained their experience during practice. The idea behind designing questions was tracing down the research question in such a level to be understandable by students. In order to do that, prepared written questions were presented visually and orally for students after conducting the workshop (see Appendix C). Then by handing out blank sheets they were asked to write their ideas. Since the activity took place in two days, the questions of first day were altered somewhat in order to make the questions more clear.

Written answers were simple and short. Although many groups were consist of three students, a student of each group wrote the answers on behalf of the other group members. This pattern were similar for all groups. None of students answer the questions individually. They talked to each other and then wrote their ideas by one person. However, one group left the paper blank without any feedback. A few original responses are attached in Appendix E.

A group of three girls wrote:

- "We thought it was fun, but it was complicated with the LED lights. Sheila likes programming scratch and Maria likes connections. It was fun. It was fun, super fun, interesting, fun characters".

Some groups consist of two boys and one girl expressed as below:

- "It was great fun and interesting things to do and it went well. Because I have never guessed this. Connection and fabrics".

- "It was exciting to mix craft and technology to make it a hard objects. Then the needles would not go through the joint. But it was fabric so it was easier to go through. The programming was fun because we never did it before. Everything else we have done before".

- "It was quite interesting. We managed with all the links. We found connections to be most interesting"

Some groups of students emphasized on the fabric in their reflections:

- "Yes, it was interesting to mix technology, because I like sound and my friends also like handicraft. Designing fabric by using hands was very interesting, because it was fun to make shapes/characters and cutting that to paste on something".

- "Does the fabric have a meaning? We think it will be much easier and a bit more fun is just connecting cables with computers, etc. What was fun with the whole task was when we created the figure itself and glued and when connecting the cables with the lights."
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*The most interesting thing was when all four lights started to light and when there was sound using a motion*”.

- “The importance of the fabric. With time, it is more fun to connect circuits. You want to do more”.

- “It was harder to say the connections because there was fabric in the road. The funniest thing was to keep up with the programming and it was a good idea to make the old man. It was exciting to go to school”.

Students were requested to express which part of activity was more interesting for them, so that I classified their responses in figure 7 to make it more explicit. As shown, more than 50% of participants were interested in blending technology with programming and textiles. Similar results have been seen in students’ interest in electricity connections and programming distinctly. Programming was the part which indicated maximum interest by students with no negative response. According to responses, audiovisual aspects of Scratch programming language were the significant reason of this interest. Conversely, according to their answers working with textiles took fewer interest, so that four groups of students specified they were not interested in working with textiles at all.

![Figure 7 - The summary of students’ responses presenting students’ interest.](image)

### 4.2 Interview

The interview has been done with teacher who participated in activity three month after conducting the workshop. Since the students’ answers to questions were simple and short, it was need to provide more information and data from teacher. The importance of interview with teacher can be considered from two perspectives. Firstly, the teacher’s idea and evaluation about the workshop and its comparison with the daily activities at school. Secondly, the students’ reflections after taking part at workshop to investigate whether it impacts their interest to STEM. The interview questions (see Appendix D) were planned to encompasses both research questions and deficiencies for further researches. Interview took 30 minutes and has been done at their school. In order to respect the ethical considerations a consent letter signed by interviewee before conducting it which allowed me to record the interview.

Mathilda, a seven years’ experienced teacher in 4th, 5th and 6th grade believed that there is not any connection between current making activities at school and technology as future needs. She thought that although according to Swedish educational curriculum students have to attend 80 minutes per week in compulsory workshops of wood, metal, and textiles, they are not linked
Influence of soft materials on student engagement with STEM

to each other. She mentioned that there is a need to blend technology lessons with programming and materials. Regarding the workshop she stated that it was a new experience and setting for her and for students as well and they enjoyed it very much. However, the workshop duration was not enough and needs to be longer. “It was so short. It was more like a fun activity”, she said. She emphasized on interesting environment of workshop as the key positive point of it. Though, lack of creativity in activities was the main negative point according to her idea.

She supposed that the level of challenges were almost at the same level of students’ knowledge and skill. Nevertheless, in order to make future works more efficient, it is need to provide more information for students before holding the workshop. Although they know the basic knowledge of science and technology, by preparing them, they would catch and learn more during the activity:

“Actually because if you want them to really learn something then you have to prepare them. So, they have some knowledge before they get to the event and then after that they probably have more thoughts and how they want to develop.”

According to her experience, she believed that most of young boys use the computer for war games which is tough and hard. So, the role of soft materials like as fabrics is highlighted at this point where she told:

“It makes it much softer in the way to use the computer. …. Fabric is softer and then the event got softer because you use the fabric.”

Mathilda assumed that this activity did not play a specific role for making pupils more interested in future needs and skills. According to her idea, students found it more exciting rather than an inspiring activity to motivate them for being engaged with STEM. In addition, she stated that for maximum engagement, the subject should be selected according to real-life demands and needs:

“It needs to be something that they can relate to. Something that they can use in their world. It could be useful for them in the future, in their environment, where they live, where they work.”

Considering this fact, she noted that students did not comprehend the purpose of our activity and understood it only as a funny thing to do.

4.3 Observation

The first activity in workshop was introducing the items which students were invited to use for co-design practice. As already mentioned the main items were including Makey Makey toolkit and its associated Scratch programming language, the fabrics and the angry birds themes for connecting soft material to circuits. Looking at the students during the introduction session showed that they are very interested to topic and they focused on presentation. However it seemed to be not clear since it was their first experience of having different skills together. The quiet atmosphere of workshop broke when the stimulation section performed after the introduction.

The importance of conducting this part was because of two main objectives. Firstly, motivating students to take part in workshop activity, and secondly, creating questions in students mind to
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think about the technological solutions. In order to achieve these goals a simple tricky method was deployed during the practice. The activity included chopping a carrot with a steel knife while it was connected to Makey Makey toolkit and computer. At the moment the knife touched the fruit a scream sound was played by computer speaker (See figure 8). The carrot was connected to Makey Makey toolkit through an alligator clips. A thin copper wire which was hidey connected to hand was attached to toolkit. The whole circuit was completed by taking the metallic knife and touching the hidden wire at the same time. The students became happy by the first try and it was similar for all groups. They laughed and wanted to see it again. Then they tried to do it themselves one by one and listened to the sound but because of mentioned deployed trick they were not successful to accomplish the task. In this way it was possible to give them this opportunity for thinking about the reasons of unsuccessful process and find the resolving way. Nevertheless, the students were informed about the correct way of making circuit after a couple of trying.

![figure 8 - Tricky screaming fruit](image)

At this stage students were ready to experience the main activity at their stations. They all started with cutting the fabrics and using the glue to make the selected angry bird. At the next step, the LEDs were attached to fabric and students tried to fix them in desirable positions like as eyes, ears, and cheek. Then it was the connection turn between the fabric and Makey Makey toolkit. It was the part that needed more attention in order to link the wire dual alligator clips in appropriate place on toolkit. Almost all groups asked questions regarding the correct links and they needed help to distinguish the positive and negative poles of the LEDs as well as toolkit. I would rather to name this step “the meeting point of textile with science” due to connection of handicraft fabric with electric circuits. Programming practice accompanied by making different sounds was conducted as the last part of activity to create a speaking fabric bird with turned on LED lights. Again, I label this part as “the meeting point of textile, science, and engineering”.

Looking at the students behavior throughout the activity illustrated similarities and differences. The main similarity was the students’ interest in sounds when they experienced the programming section. They liked to play with sounds and make different effects as the output of programming. Some groups were very excited and tried to create a simple music rhythm by iterative sounds in different periods. Another similarity to be considered was their struggling in fixing the LEDs on fabric and making correct circuit. The students had to work on both sides
of fabric. While the front side was the artistic textile handicraft, the back side was consisting the connection.

The different manner happened when one group of students gave up to continuing connecting the alligator clips on the back side and decided to do all connections in front side by using the aluminum foil. Although the shape of angry bird which has been built by them was not beautiful, but the circuit was completed and worked well. The interesting point I considered as the main dissimilarity was comparison of activities order which followed in different groups. While a group of students including three girls spent the half time of workshop on making the fabric, a group of three boys carried out both textile and programming tasks simultaneously. Majority of girls focused firstly on working with fabric and paid much attention to create beautiful shapes, then by completing the handicraft they began to look at the screen and toolkit. On the other hand, the boys enjoyed the sounds from the beginning. One of them worked on handicraft and two others played with Makey Makey and Scratch.

4.4 Video recording

Looking at students’ activity in recorded videos illustrated different behavioral and phenomenological characteristics at workshop like as concentration, happiness, boredom, excitement, team working, and etc. The data is gathered from four cameras which recorded the activities of students during the workshop. Groups characteristics and gender composition is described in table 1. In order to classify these features, I looked at the notion of engagement from different perspectives both individual aspects and social ones. Then by watching the videos and comparing them with each other similarities were determined and the time students were spending on them were measured. The result indicated four major levels began with attention and ended with social interaction. I labeled them the levels of engagement as attention, motivation, engagement, and social interaction development. In order to find out which activities are classified in which level, behavioral aspects were considered as following:

Attention (see Figure 9) mostly refers to students’ consideration at the beginning of workshop when the introduction session performed. It followed by focusing on presented information in order to get familiar with practice to be during the workshop. It was the most silent part of workshop where they listened to descriptions about the toolkit, making, and programming. The time which students spent on this part were almost similar to tutorial introduction. They looked at the equipment and touched them on the table like as wires, clips, Makey Makey toolkit, computer mouse, and fabrics. Since the topic was new to many students, they asked some questions about the activities and Makey Makey toolkit as well.
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Motivation is referred to specific behavioral reactions which have been done by students before, during, and after engagement with activity (see figure 10). Stimulus activities like as laughing, playing with devices, singing, wondering, jumping, having fun, and dancing took place as motivational aspects. When students were happy to work with toolkit, it showed that they are motivated to accomplish the job. Particularly it happened when they were experiencing the programming skills by Scratch programming language. A boy was very motivated by pressing the keyboard buttons iteratively to play the sounds. He moved his hands similar to dancing and sang repeatedly.

I considered the Engagement level (figure 11) as the whole devoted time that students spent for doing assigned activities. It normally started by making the fabrics, then followed by electricity tasks and ends by programming activity. However different groups showed different patterns in specified time for mentioned activities. Whereas in one group they did a group working to meet the mentioned schedule, members of another group started it individually with programming and making at the same time. The engagement included making the Angry birds textiles, adjusting the LEDs to fabrics, connecting LEDs and wires to Makey Makey toolkit and computer, programming, and working with tools and devices as well. One specific feature
of this part was including the problematic situations which students faced. Connections and programming were activities which needed more attention to do appropriately. Students tried to solve the problems either themselves or by getting help from teachers. Although the easiest part seemed to be the textile making, working with hot glue gun looked problematic for students. At the beginning they often burned their fingers while trying to stick fabric patches on each other, but by continuing they learned to work with it properly.

![Figure 11 - Engagement examples captured from recorded videos](image1)

Social interaction development is referred to collaborative interaction of students during maker movement activities at workshop (figure 12). While students worked with each other to make the fabrics and connections they talked to their partners from same group and also other groups. The social aspects were exemplified in those interactions which students helped each other to solve the problems and to share their experiences. In order to solve problems some friends moved between different stations to see how their friends are dealing with connections. In one station consists of three students, for instance, six pupils gathered in some moments. When they noticed that the camera is recording their activities, some of them liked to look at camera lens and make connection with their further unknown audiences. It was interesting to see how they are motivated to present their work through camera. Some students made funny facial figures in front of camera. In order to enhance these social communication, they were requested to present their workshop output to other groups.

![Figure 12 - Social interaction examples captured from recorded videos](image2)
It is important to mention that although I divided students’ activities in distinct levels, their behavior could be classified in other levels. However, disregarding the overlapped time, the portion of time which every group spent on mentioned levels are presented in table 1.

Table 1 - Time specified for levels of engagement

<table>
<thead>
<tr>
<th>Group No.</th>
<th>Gender Composition</th>
<th>Workshop specified time (%)</th>
<th>Attention</th>
<th>Motivation</th>
<th>Engagement</th>
<th>Social interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.1</td>
<td>3 girls</td>
<td></td>
<td>19</td>
<td>10</td>
<td>57</td>
<td>14</td>
</tr>
<tr>
<td>No.2</td>
<td>3 girls</td>
<td></td>
<td>11</td>
<td>7</td>
<td>71</td>
<td>11</td>
</tr>
<tr>
<td>No.3</td>
<td>2 girls 1 boy</td>
<td></td>
<td>7</td>
<td>20</td>
<td>48</td>
<td>25</td>
</tr>
<tr>
<td>No.4</td>
<td>2 girls</td>
<td></td>
<td>27</td>
<td>14</td>
<td>57</td>
<td>2</td>
</tr>
</tbody>
</table>

As illustrated in this table, the specified time in different groups for each level was not similar. The only similarity is the longest time which has been spent on engagement level for all groups. The engagement is the level which shows more than 50% of total time of workshop. From my point of view, the reason relies on this fact that other levels can be consider as preliminary steps toward being engaged in activity. Another point to be mentioned is looking at spending time from the gender composition prospect. In groups number 1, 2, and 4 which girls are in majority, the attention level is higher than the group including two girls and one boy. The motivation and social interaction levels demonstrate inverse trend, whereas group number 3 has higher spending time. It can be interpreted that high value of motivation in group number 3 is the factor which impact attracting other students to make a higher social interaction. It is also illustrated a correlation between attention and social interaction in groups 3 and 4, so that while attention is increasing, social interaction is decreasing affectedly and vice versa.

Moreover, in order to determine the position of each attribute, the summary of main features of them is described in table 2. Each feature is considered as a level which is in connection with other levels. This table is used in discussion chapter to come up with a diagram which shows engagement levels connection in detail.

Table 2 - Summary of engagement levels description

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>- First level</td>
<td>Focusing on introduction session</td>
</tr>
<tr>
<td></td>
<td>- Pre-level to get motivated and being engagement</td>
<td>Theoretical knowledge acquirement</td>
</tr>
<tr>
<td></td>
<td>- Correlated with partial engagement</td>
<td>Getting familiar with toolkits/equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Planning the activity/schedule</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thinking about the questions</td>
</tr>
<tr>
<td></td>
<td>Motivation</td>
<td>Interest</td>
</tr>
<tr>
<td></td>
<td>- Second level towards engagement</td>
<td>Enjoyment</td>
</tr>
</tbody>
</table>
Influence of soft materials on student engagement with STEM

<table>
<thead>
<tr>
<th>Engagement</th>
<th>Social interaction</th>
</tr>
</thead>
</table>
| - Mutual correlation with engagement and social interaction  
- Basis of keeping in flow state | Having fun  
Satisfaction  
Acquiring better results |
| - Third level  
- Including partial and overall engagement  
- Require both motivation and attention  
- Moving towards social interaction | Practical phase  
Accomplishing tasks  
Problem solving  
Experiencing new challenges  
Combining STEM disciplines  
Do-it-yourself (DIY) activities  
Do-it-with-others (DIWO) activities  
Feeling satisfaction |
| - Fourth level  
- Depending mostly on overall engagement  
- Influencing both motivation and engagement  
- Has been shaped in three forms | A common outcome of workshop  
Group working  
Sharing experiences  
Presenting the results for others |
5 Discussion

It has been acknowledged in past decades that there is reduction in number of students who graduated in Science, Technology, Engineering and Mathematics (STEM). By recognizing this declining trend, educational developers at different levels have designed various student engagement programs in order to attract students in STEM and retain their interest as well (Ross et al., 2017). In addition, these programs are impacting the student future career choice by inspiring personal preferences, motivation, and interest (Buechley et al., 2008). Considering the fact that students will contribute in activities which they enjoy (Shernoff et al., 2003), this study aimed to explore student engagement with programming and electricity, and STEM in general. By using soft materials like as textiles, children and computer interaction has been also studied. During the workshop participants engaged in designing, building and adjusting physical and digital objects in a maker movement approach. Students shared a collective set of values while they played, made, repaired, and cooperated in activity. The toolkit and programming software used in workshop provided a context to develop their creativity and innovation. This section will investigate more deeply the results of the study, highlighting what I consider to be the most important raised in the workshop to answer the research question.

It should be mentioned that although my standpoint in analysis of data as an information system researcher is concerning to be independent, my background and experience in textile engineering may shift the interpretation to be focused on textile part. Denzin (1989 cited in Mehra, 2002, p.7) clarified the researcher bias according to his/her experience: "Interpretive research begins and ends with the biography and self of the researcher. ... So the researcher bias enters into the picture even if the researcher tries to stay out of it." Nevertheless, I continuously see my role in order to not be influenced by my background preferences.

The discussion is categorized in three sections. Firstly, based on empirical findings I defined an engagement level diagram to describe the whole activity from the standpoint of it. The research question is mainly answered in this part. Secondly, it is discussed the role of textiles in student engagement, and thirdly, results have been evaluated again under the light of flow theory.

5.1 Engagement Analysis

In conducted workshop different fields of technology, programming and textiles were combined in a making activity. Every subject has its potential to attract students in the field. For example it was seen in workshop that connections, wires, and lights in electric part were the factors which students liked. In programming, the interactive design of blocks used in Scratch language and the sound effects were more interesting. Similarly, in textile part, students were working with soft materials, scissor, glue, and other things which placed participants at the middle of a making activity. When these subjects are simultaneously blending together their attracting potentials will be amplified to engage students more with STEM. In order to answer the research question and investigate how this combination impact the engagement, I analyzed it in two subdivisions: Observation and video recording analysis, and student/teacher interview analysis.
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A - Observation and video recording analysis

As stated in empirical findings, according to observation four attributes of attention, motivation, engagement and social interaction were demonstrated by students at workshop. I considered these features as the symbols of engagement with STEM. Although these traits had different arrangements in different groups, a general pattern has been seen in whole activity. I illustrate different levels of engagement and their connections to each other in figure 13. As showed, attention was the first level to be considered. It was highly dependent on surrounding settings and conditions provided for students. The introduction session played an essential role in creating maximum attention. It delivered a brief explanation about the practice, textiles, toolkit, and programming language. However, since it was only the theoretical part it seemed like students did not distinguish what they are expecting to confront clearly. The next level was motivation. Although both attention and motivation are primary steps for being engaged in the activity, the motivation has an essential role to shift the attention towards engagement. These two levels are similar to three aspects of concentration, interest and enjoyment argued by Csikszentmihalyi (1997 cited in Shernoff et al, 2003, p.3). He noticed the importance of these phenomenological features to achieve cognitive engagement. What I reflected as attention is similar to concentration that is a deep absorption in an activity. I referred to motivation also with partly same meaning of interest and enjoyment. It helped students to stand in flow experience with the feeling of satisfaction for continues engagement. Here, I highlight the role of stimulation part which was conducted after introduction section. It was a mediator to convert the attention to motivation and brings many questions in student minds. In other words, it helped participants to enter the activity with a motivated and energetic feeling.

![Figure 13 – Engagement levels diagram](image)

The observation at the workshop and data collected from recorded videos also demonstrate that attention and motivation play an important role at the beginning of activity. However, when engagement level has been achieved, three mentioned levels augment each other simultaneously and continuously. I displayed this relation by dotted arrows in figure 13. As shown, moving towards engagement is not an one-way connection. Motivation creates engagement and at the same time being engaged impact motivation. Similar pattern was seen for attention. While the attention at the beginning of workshop was due to introduction session by providing appropriate information, the further attention was the result of engagement. It means that students need attention to do the tasks completely.
The next step as shown in figure 13 was engagement. Since the activity was based on combination of textile with electricity and programming, engagement can be considered from two perspectives. I translate them as overall engagement and partial engagement. In order to interpret mentioned perspectives I recall again two important characteristics of any maker movement activity. As highlighted by Karppinen et al (2017), a making activity is including both DIY and DIWO tasks where participants are involving in do-it-yourself and do-it-with-others challenges. In the light of these features, I believe that the engagement level can be defined as partial engagement when students worked in distinctive sections, and overall engagement when they were involved with whole activity:

The partial engagement in specified sections was normally followed by DIY approach. In other words, do-it-yourself experiences lead pupils to engage with a specific activity more individually. For example, when students wanted to make the textile shapes they engaged in it separately. Similarly, the programming engagement had the same pattern to be followed independently. An opposite arrow from engagement to attention shows this level of engagement which need high amount of attention.

The overall engagement with whole activity, on the other hand, is compatible with DIWO approach. For instance, when they combine the textile with electricity or programing, they engaged in activity with a group work effort. According to collected data, this side of engagement encompasses the motivation mostly. The dotted arrow from engagement to motivation in figure 13 indicates the link between them. Accordingly, the overall student engagement with whole activity determines another important attribute in figure 13.

The last attribute derived from empirical findings is the social interaction developed in entire activity. As shown in figure 13, the social interaction mostly is seen at motivation and engagement levels where students were motivated and engaged in activity, rather than when they paid attention to tasks. The specified time which students spent for attention and social interaction levels confirms this matter. As illustrated (see table 1), by increasing one, the other decreases. It is also well-matched with one important aspect of maker movement activities which is DIWO notion (Karppinen et al, 2017). What I considered as overall engagement in workshop leaded to social collaboration of students. The social interaction, a supportive community context, and a self-directed learning with assistance of others are the positive impacts of constructivist approach (Dewey, 2004; Papert, 1991 cited in Blikstein, et al., 2017). In addition, the social aspect was formed in three levels:

- Peer to peer collaboration at the same group
- Communication between different groups,
- Student-teacher interaction

In order to steer this social interaction as a common outcome, pupils were asked to exhibit their work and findings in the presence of others in order to share their experience during the activity.

**B- Students/teacher interview analysis**

At the end of the workshop, students were requested to write their feelings about the practices according to prepared questions. Except one group of students other groups found it very interesting as Sara emphasized on exciting facet of workshop to say: "... It was fun. It was
fun, super fun, interesting, fun characters”. Summary of responses (see figure 7) makes explicit some similarities as well as differences. Almost all groups perceived it interesting to combine technology with programming and handicraft. When it is designed with audiovisual aspects like as LEDs and sounds, students expressed more exciting responses where one group stated “... it was exciting and interesting. The most interesting was the sound”. Likewise most of them noticed that it was their first experience to combine circuits, textiles, and programming together at the same time. The common view as demonstrated in their answers was the fact that doing such activity is interesting.

One distinguish point specified by two groups was the strange role of textiles in whole activity. Their answers illustrated that they did not found textile to be relevant with other components. Although they were interested in making the shapes by fabrics, glue, and scissor, but they understood no connections between handcrafting and computer. For example, it is noticeably stated that “does the fabric have a meaning?” with a strong question mark at the end of sentence. Similarly, other group mentioned that “It was harder to say the connections because there was fabric in the road” which shows students’ thinking about the role of textiles in the road of this combination. In subsequent section more details of students’ interest and engagement with the presence of textiles will be discussed. For now, it is stimulating to indicate simple facts in the gathered data.

Interview with teacher who accompanied students in workshop appeared some points to be considered. First issue was the lack of connection between subjects of technology, materials and computer science in current curriculum of educational settings. According to her idea these subjects look like separately islands which needs to be connected. She believed that there should be a bridge to connect those subjects together. It helps students to have a better understanding of them for further engagement with STEM. Here, role of workshop was highlighted to create such linkage in a funny and joyful making movement, she thought. As a matter of fact, connection of textile with digital toolkit and its embellishment with LEDs provide a novel view in pupils mind. Second point was the lack of creativity in performed activity as a negative point. Since textiles were pre-designed before holding the workshop, the students could not make desirable objects according to their interest. In other words, this approach did not provide opportunity to think about real needs and favorites, as she stated “it should be something that student can relate to”. Third issue was lack of efficiency of workshop. Since it was new subject for both students and teachers, it is a need to prepare them before doing the activity. Except the playful features of workshop to connect technology, programming and textiles, it did not give students adequate perception about their future job preferences. In order to makes it happen, it requires replication of such workshops, following with providing sufficient knowledge and information about whole activity before conducting it.

5.2 Soft materials influence on engagement

Here I focus on influence of soft materials on engagement of pupils with technology and programming. Although based on students perspectives, textile part was not as interesting as other parts, video recordings illustrate that they spent much time on it. Looking at empirical findings from workshop, students spent considerable attention and effort on designing Angry birds fabrics with LEDs (see figure 14). Most of groups devoted a lot of time to make the fabrics in best shape of possible. Actually, the LEDs were used as a decorative element to make the fabric alive.
According to Kafai & et al (2014) the widespread interest in combination of textiles with electrics is rooted in DIY characteristics of it. They consider it as an opportunity for breaking obstacles of computing. I believe that using textiles has some features which make them particularly persuasive for students. Firstly, I look at textiles from a broader perspective. Considering the role of textiles in everybody life, it is more important for young people who are seeking their identities, especially ones who are publicized through the clothes and handmade objects. According to Buechley et al (2008), electronic toolkits in combination with soft materials are gradually becoming more important in fashion industry. There are two features which make them impressive: monetary value and ability to promote social links. Combination of crafts with electronics like as e-textiles delivers a cutting-edge technology that students are able to personalize it according to their interest. In other words, they can integrate it into their everyday lives. It is also noticed by interviewee that “It needs to be something that they can relate to. Something that they can use in their world”.

Secondly, I considered aesthetic nature of textiles when blend with technology. The electronic and computer science are not typically comprising artistic content. However, according to Buechley et al (2008), topics of engineering and art are not intrinsically far from each other. Such separation causes deficiency in two ways. Lack of diversity in practitioners (for example those who come to be computer experts and electronics engineers), and lack of diversity in produced artifacts by them. Presence of textiles in the workshop made an artistic medium which provided exploration of art and engineering at the same time. It acts as a motivation factor for better engagement of students with STEM activities. The teacher stated at interview that the common use of computers are in war games specifically by boys. She believed that technology and computer in the presence of a soft and colorful fabric simply makes them softer and more joyful. It is derived from the interview that, not only the textile makes the technology softer, it provides the whole event more friendly and encourages students to engage with the activity. Some scholars add art to STEM and stated it as STEAM to emphases on the importance of art in combination with other parts of this discipline (Basham & Marino, 2013). Moreover, as denoted by Yoo (2012) a new form of materiality is defined when textiles are blending with technology.
Thirdly, using textiles beside technology turns attention to another important issue of male dominance in electronics and programming. Buechley et al (2008, p.431) pursued this angle by asking how girls get participate in computer science. In addition they asked: “how can we integrate computer science with activities and communities that girls and women are already engaged in?”. Here, the role of textile is highlighted. Students, particularly girls, designed it with specific attention more successfully and enthusiastically. One of them mentioned: “Designing fabric by using hands was very interesting, because it was fun to make shapes/characters and cutting that to paste on something”.

5.3 Student engagement from the flow theory perspective

The discussion in previous sections demonstrated two points of views. First, students engagement with activities they carried out in the workshop, and second the factors which influenced this engagement. Formerly, I reflected the different phases in which the engagement shaped, and then I considered the role of soft material as a mediator to impact the engagement. However, bearing in mind these aspects together guided me to look at them from the perspective of flow theory. The reason I got persuaded to overview the gathered data from this angle is similarities of engagement phases with main concepts of flow theory. I displayed the impact of textiles on engagement by modifying mentioned theory as shown in Figure 16.

As already stated, the cognitive engagement with an activity is the consequence of embracing three features of concentration, interest and enjoyment (Csikszentmihalyi, 1997 cited in Shernoff et al, 2003, p.3). In an activity, while deep concentration and rich absorption are accompanied with adequate interest, the flow state will being experienced. According to Shernoff et al (2003), people absorb in an activity with an inherently enjoyable sense. The flow state can improve the engagement by further motivation. It helps to keep the engagement with a feeling of satisfaction (Shernoff et al, 2003). Most of above cited characteristics have been seen in phases of engagement which I expressed in table 2. As emerged from empirical findings, blending technology with programming and soft material helped students to be positioned in flow experience (see Figure 15 (a)). Nevertheless, according to interview data, it is need to provide prior knowledge for pupils about the technology before conducting the workshop. It shows that the level of activity was not balanced with students skill which leads to move outward of the flow state. It is worth to state that the flow experience has been seen distinctly in programming, technology and textile parts, rather than a flow state in whole activity. According to recorded videos and observation three types of behavioral, emotional, and cognitive engagement have been seen in workshop by participants. As stated by Fredricks et al (2004 cited in Jeffery, 2017, p.2), behavioral engagement refers to social participation; emotional engagement is relevant with students’ relationship with others; and cognitive engagement is an enthusiasm to solve the challenging tasks for additional knowledge achievement. In figure 13, while behavioral and emotional engagement are more related to social interaction level, the cognitive engagement was seen in working with Makey Makey toolkit and programming. Furthermore, from the gender perspective, where the flow state were experienced based on cognitive engagement by boys, it was more on the basis of behavioral and emotional engagement by girls.
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Though, as shown in figure 15 (a), many students felt the flow state because of engagement levels discussed before, I can declare that it was not complete. Here, the role of textiles is underlined to impact the flow state. As derived from interview and students responses, existence of fabrics beside other parts like as electrics and programming makes the whole activity softer. Mathilda specified that “Fabric is softer and then the event got softer because you use the fabric.” Bearing in mind this point in addition to artistic characteristics of them which already mentioned, I consider soft materials such as textiles as a capable factor to push the borders of flow state into a wider extent. As shown in figure 15 (b), a flow expansion will be occurred while the soft material is blending with technology and programming in an maker activity. As described earlier, boundaries of flow state are brittle and switch interchangeably with anxiety or boredom (Nakamura, J. & Csikszentmihalyi, M., 2009). So, I believe by means of textiles these borders become blurred. As a consequence, it helps to retain participants being engaged in activity, particularly from a gender perspective I argued before.

6 Conclusion

6.1 Conclusion

Considering a lack of interest in Science, Technology, Engineering and Mathematics (STEM), variety of activities and programs have been organized by education providers to create appropriate engagement and retain it as well. In recent years, looking at computer science and programming as important learning skills, it is also a need to explore the student engagement with digital technologies. The maker movement, by emphasizing on role of making at education is an approach to recall this engagement through designing, building, and repairing objects physically and digitally. In this master thesis the combination of digital technologies, programming, and electronics provide an opportunity to investigate students engagement with STEM by using textiles to influence this engagement. Through this study 60 students of age 12-13 (grade 6) were participating in a workshop held at Linnaeus university, Växjö, Sweden. Data collection method was organized on the basis of observation, video recording, and semi-structured interview in the light of an interpretivist qualitative research paradigm. However,
a quantitative approach was deployed in analysis part to demonstrate numeric comparisons. Moreover, in order to ensure validity, reliability, and meet ethical considerations related to research with children, the written technique has been applied for data collection from students. So, they were asked to write their answers rather than conducting direct interview.

The findings of this study indicates that many of students who participated in workshop passionately engaged in almost all parts of activity. It fosters the social interaction of students during and at the end of workshop. Empirical findings demonstrated that the combination of Makey Makey toolkit with Scratch programming language and textiles provide four levels of Attention, Motivation, Engagement, and social interaction. These levels pursued by students which shaped the final desired engagement. While these levels were related to each other, every factor affect others. Connection between four levels is demonstrated trough a figure which I named engagement levels diagram. However according to findings, students perceived the activity more fantasy rather than encouraging them to learn future needed skills.

Looking at influence of textiles as soft material showed that its combination with electronics and programming provides an artistic medium to blend art and engineering. At the same time it is a motivation factor for better engagement of students with STEM activities. Since the digital tools are normally made of hard components, they enjoyed fabrics which are soft and comfortable when holding or working with them. In addition, the soft and colorful fabrics make the technology and whole event softer, friendly, and joyful.

Bringing in mind the flow theory as a model to show the features of engagement in an activity, the combination of STEM subjects in presence of textiles can impact the flow state. This combination by relying on soft materials, influence flow state borders to be wider. Additionally, considering the breakable boundaries of flow state to be changed with anxiety or boredom, I believe that these borders become blurred by using textiles, so that it helps students to being kept in engagement and flow state as well.

6.2 Implications for Future Research

The simple textile materials, in my view, is a mediator for making technology softer in order to encourage students to be engaged in learning technological and digital skills. In particular, as I mentioned earlier it is an opening for girls to be involved in such activities. First of all, as I discussed in my thesis, the technology, programming and textiles were combined in a maker activity to enable students experience some parts of STEM at the same time. It also empowers educators to conduct similar workshops according to their facilities. However, in order to take more advantage of these events, as argued in interview, it is important to provide a setting towards developing creativity. In other words, instead of directing students to make what was pre-designed for them, let them develop their own favorite objects. When they make what they like, it is more interesting for them with a long term effect. In this study, the textiles were used in their basic form. Then, in order to take maximum benefit of textile, it is suggested to use conductive materials like as conductive thread and fabrics to make real e-textiles. By investigating the role of e-textiles in similar activity and comparing the results with current study, it is possible to understand the influence of soft materials in student engagement with essential skills. Likewise, there are many novel technological toolkits that can be used in place of Makey Makey to connect textiles with programming more effectively. By using them it can be determined the better ways of student engagement with STEM.
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Appendix A.

Consent letter

To custodian with children in the relevant classes at the ………. school

Hello,
My name is …………. and I am studying a master's degree in …………. at Linnaeus University. As part of my education I will write a master's thesis and will be in the process of conducting a study of students working with digital aids technology. Students from the ………….. School are invited to Linnaeus University on Monday 12/2 and Tuesday, 13/2, to work with challenging mathematics and technology with digital aids. The students will work in smaller groups, about 5 students in each group. When working with digital aids technology, I want to, as well as researchers I collaborate with Linnaeus University, make audio and video recording during the lesson. We have the desire to be able to use this in future studies but also be able to show the lesson in academic contexts such as meetings with other researchers, teaching for prospective teachers and for educational purposes.

We therefore want to ask you as a guardian for permission for your child to participate in these studies. The purpose is to contribute with new knowledge that can inspire better teaching and learning conditions for pupils' learning and development. The study will be summarized as follows:

All collected audio and visual material will be handled confidentially and recordings will be stored according to research ethical guidelines. Students participating will be anonymous in the studies, the school's name will not be mentioned, and otherwise it will be written so that no individual will be able to identify. Anyone who participates is free to cancel their participation at any time if they wish.

I hope to receive your permission as guardian for your children to participate. Please talk to your child about this and fill in the fields below and submit it to me or any of the teachers at the Green Column School.

If you have questions, please contact me
……………….@lnu.se
Tel: …………..

☐ I have read the information above and agree that my child will participate if he or she so wishes.

☐ I have read the information above and do not agree that my child is participating if he or she wishes.

............................................ ..........................
Pupil's name The custodian's signature

............................................ Date
Appendix B.

Consent letter to participate in interview

My name is Ali Hamidi and I am studying information systems master program at Linnaeus University in Växjö. Since I am working on my master thesis with the topic of development of student-computer interaction through maker movement activities, I need your participation to be interviewed in order to complete my data analysis.

Information about the study

Nowadays the digital technology has disrupted the way people do their works in every sector. While the widespread acceptance of digital fabrication in educational environment is being increased in last years, less has been explored in this field about the effectiveness of these technologies with the aim of supporting the future learning skills. It is also a need to investigate the students interest for sufficient engagement with digital technology through maker movement as a learning methodology specifically from a gender perspective for girls and women. Here the combination of digital technologies with soft materials like as textiles is providing ideas’ creation and innovation for pupils engagement with new technologies. Since the digital tools have been used by students are made of hard components, they will enjoy fabric ones that are soft, gentle and comfortable when holding or working with them.

Your roles as participant

I chose interview method to understand what teachers think about students interest towards needed skills for future. It provides valuable material to analyze the data I gathered through the workshop which has been hold in Linnaeus university on 12th and 13th of February with your participation. The expected duration of interview is 30 minutes and interviews are free to answer or withdraw questions. You also have the right to cancel the participation at any time you don’t feel convenient. It is important to highlight that you will be anonymized in my thesis report which means I will not use your real name in my thesis text.

According to your consent I am authorized to record the interview for further transcription in order to achieve appropriate information from your interview. However all collected audio recording will be handled confidentially and stored according to research ethical guidelines.

If you have questions, please contact me (email: ah223vd@lnu.se Tel: 0046-70-351-4108)

☐ I have read the information above and agree to participate in interview and record it

☐ I have read the information above and agree to participate in interview but not record it

Name and signature

Date
Appendix C.

First day questions:

- To what extent this activity helps you to understand the technology and its application?
  If yes, then how?
  If no, then why?

- Which parts were more interesting for you?
  a) Design/making
  b) Electronics
  c) Programming
  d) Textiles/fabrics

Second day questions:

- Var det intressant att blenda teknik lektion med programmering och textil?  
  (Was it interesting to blend technology lesson with programming and textiles)
- Varför/Varför inte?  
  (Why/Why not?)
- Vilken del är mest intressant?  
  (Which part is more interesting?)

  a) Design av tygfigur  
     (Design of fabric shapes)
  b) Programmera scratch  
     (Programming with scratch)
  c) Kopplingar  
     (Connections)
Appendix D.

Teacher Interview questions

What are current activities related to making? Is there any connection to technology?

What is your idea about the workshop we did together?

What was the students reflection after workshop?

Do you think how it is possible to improve the output of similar workshops in future?

Do you see any difference in students’ interest before and after conducting workshop? If yes, in which field?

Was it interesting to blend technology lessons with programming and textiles? Why?

Which part was more interesting? Why? (from your perspective and students perspective)

What is the role of textiles in between?

How is it possible to motivate students to learn skills related to future needs? An example she/he did…

In which ways do you think students can be engaged with STEM and technology more efficiently? An example she/he did…
Appendix E. 
Examples of students answers

Har ligger ett betydelse?

† tycker del för att det blir mycket
lätta och litet avgörare, än att bara koppla
sladdar med datorer osv.

Det som var roligast med hela uppgiften
var när vi skapade själva figuren och lämnade
och när man kopplade sladdarna med
lamporna.

Det mest intressanta var när alla fyra
lampor började lysa och när det kom
lyd med hjälp av ett företeelse.

Tisdag pass 1
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A. Det var spännande att bli med och arbeta. Det är att uppvisa skillnader i enmallade möten

2. Programeringen var roligt

för att vi har aldrig gjort
det innan. Allt annat har vi gjort
innan.
Influence of soft materials on student engagement with STEM