Finding Fun: Characteristics of Non-Formal Technology Education in Oulu

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Abstract

Education is not a singular, straight line from kindergarten to a diploma anymore for everyone. It is important to know and acknowledge the different types of out-of-school learning experiences young people can embark on in the quest for mastering a trade or just to have a good time. In this exploratory study into the world of non-formal technology education in the area of Oulu, Finland two different instances of varying levels of non-formality were investigated and how participants find fun in these situations since it is apparent that if something is non-mandatory to attend to, there should be some type of enjoyment found in the process. Tiedekoulu and Koodikärpät-kerho are clubs geared towards children and teens that have interest in playing with, making and programming technology. The observations with field notes were done in five different types of programming clubs and three different robotics ones with interviews that were conducted with 10 participants (ages 8 – 17), 6 parents and 6 instructors from these clubs. From the previous literature the practices and qualities of non-formal education could be defined, what fun is and how it manifests in children while they attend pedagogical situations. From this framework, the results of the analysis suggest that there are three main ways children and teenagers have fun in non-formal education: fun from the tasks they are doing, social fun by sharing with other attendants and pedagogical fun with instructors. Some attributes of the observed clubs were categorized as well along the lines of formal/non-formal/informal and the practices of the clubs were explored. Besides these findings, the limitations and implications for future research were also looked at.

Keywords
non-formal education, after-school clubs, out-of-school learning, robotics, programming, maker, children, teenagers, fun,

Supervisors

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Foreword

This thesis was a part of the COM'n'PLAY SCIENCE –project funded by the European Commission and supervised by two knowledgeable academics with a long history in HCI and CCI. Therefore I would like to thank Professor Netta Iivari and Senior Research Fellow Marianne Kinnula for this opportunity for me to have a look into how the next generation of computer enthusiasts get their drive to experience the wondrous world of technology. This work has taught me a lot outside of the scientific repercussions with my "first real job" experience and the courage to go out of my comfort zone.

I would like to thank the people from Buutti Education and Suomen Tiedekoulu for their excellent cooperation while I was conducting the observations as well as to all of those who have personally contributed to this thesis by giving consent to the research and interviews.

Thank you to my office mates and colleagues for their patience when I was asking them stupid questions about how to do research as well as their remarkable advice. I thank my mother Piia, Venla and Louay for letting me vent and aiding me find my balance. I promised to put my brothers' names in this thesis as well, so thank you, Ilkka and Mikko, for being there for me during my writing process in spirit.

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Contents

1. Introduction

It is extremely important to empower children to make their own choices and let them do as they see best in their lives. Us adults are great at deciding, designing and developing things that younger people should or can do but in the world of scientific research, it is implored that different user groups be represented in their own right as agents and actors of their own volition. By bringing the Science and Technology, which are the two first letters in STEM others being Engineering and Mathematics (Krishnamurthi, Bevan, Rinehart, & Coulon, 2013), closer to children, they might get interested in it in a way that we as outsiders cannot foresee. We as researchers can try to breach the gap by developing more child-friendly ways of experimenting with technology as well as examine those that already exist (Eisenberg, 2013). Technology education is the chosen term for this study since instead of STEM, it is more specified but still gives a wide enough berth of subjects ranging from programming to laser cutting to be analyzed. STEM is regarded as a range of school subjects, so it is important to acknowledge. Engineering (the E in STEM) was considered as well to be the topic but since engineering has a different connotation in Finnish (relating more to work life), technology encompasses the act of engineering and the materials to do it linguistically.

By using a qualitative research methodology, it is easier to have young participants be the humans they are and not just data points to gather "data about children" (Barker & Weller, 2003), it is good for empowerment that research is done WITH children instead ABOUT them (Darbyshire & MacDougall, 2005). Fun as a concept is widely recognized in the HCI (Human Computer Interaction) community now-a-days (Blythe & Hassenzahl, 2003). Electric entertainment is usually the thing that comes to mind when there is talk about fun and technology but it is important to acknowledge the impact fun can have when performing "serious tasks" as a cognitive break and memory aid (Berk, 1996; Garner, 2006). Fun and non-formal education have not mixed as often as they probably should have in the scientific consensus. Some studies focusing on other parts of the non-formal way of education have mentioned fun as a side note, like Alekh et al. (2018), but the connections and characterizations have not been studied. The consensus for the theories this thesis is looking at comes mainly from a few areas of study: fun as a concept, fun in pedagogical situations, education as a linear of formality, the characterizations of informal, non-formal and formal education and non-formal education activities.

The research questions for this thesis developed over time and were heavily influenced by the empirical data gathered. This makes this thesis an exploratory study into the world of non-formal technology education in Oulu. The research questions were formed with the literature into the subject of fun in non-formal education in mind and to the needs of the COM'n'PLAY SCIENCE -project, which is explored and explained in chapter 4 "Methods". RQ1 and RQ2 were mostly answered by the interviews. The third research question was the center of observations and from the field notes some trends to describe the practices and level of non-formality in the clubs arose. The research questions are as follows:

RQ1: What are the practices of non-formal technology education in Oulu?

RQ2: What are the characteristics of the non-formality of the clubs in this study?

RQ3: How fun is shown and had in the clubs?

The focus in this study originally was the fun in non-formal educational situations but further on the study, other trends from the data could be picked up about the characteristics of the educational instances studied. Since the definition of informal and non-formal education were not as clear as initially thought, they are examined here as their separate entities, hence the three research questions. The summarized version of the results note that the practices of non-formal education in Oulu are: attendees discover the correct solutions themselves, freedom to choose and technology is used creatively to aid in learning. For RQ2, the two instances provided different levels of non-formality but in conclusion, the voluntariness of attendance, no diplomas or certificates, takes place outside the time and space of formal education and has instructors are the qualities that describe the non-formality of the clubs. RQ3 is answered by the framework built from the literature and the observations by fun in doing, pedagogical fun and social fun.

The research questions were answered by observing robotics and programming clubs at Tiedekoulu and Koodikärpät-kerho, which are instances of non-formal technology education in Oulu, Finland as well as by interviewing willing participants. The attendees were between the ages of 8 and 17 and there were in total 55 participants that gave consent to this study and from them 22 interviews. This consists of 33 club participants, 6 guardians and 16 instructors. Table 8 on page 47 has detailed information of the study participants. In total, it was hard to estimate the number of club attendees, approximations lay around 150 based on the reported number of attendees by interviewed instructors. The study subject for this thesis were the attendees who gave their consent either by returning the consent form given by the researcher, submitting a Google Forms document or orally giving their consent during an interview. Attendees below 18 years old were instructed to ask their parents to give consent for them, but the opinion of the attendees themselves were asked and respected as well. There were cases of parents giving consent for their child to be studied but the child themself did not like the idea. In such situations the attendee was counted in the total of subject but to respect their wishes, no recognizable data was gathered. Interviews were held for those who showed interest in the research (as well as the movie ticket promised as a reward) and by asking the parents for a well suited time for them and their children to be interviewed. In total six parents of attendees were interviewed and six instructors: three from Tiedekoulu and three from Buutti Education (the ones who held Koodikärpät-kerho).

The results from this study implicate that further research into the subject of fun is needed, especially when it comes to how contemporary pop culture (for example music, TV shows, video games and even memes) influences fun and if non-formal education has a better basis for having fun than informal and formal education. For practice, this study does not contribute in that many ways, since the performance of the children in these situations was not studied, but the underlying theme of when people have fun, they would like to spend more time doing what that feeling originates from does feed into the practical side of non-formal education as an incentive to include fun in their curriculum or programs as a sprinkle of sugar on top.

This thesis consists of two previous literature sections (Technology Education outside of the Formal Classroom and Manifestations of Fun), explanations and exploration of the methods used (Methodology), findings and results (The Instances of Non-formal Technology Learning in Oulu), discussion and conclusion.

2. Technology Education outside of the Formal Classroom

Informal and non-formal education can give students a more hands-on approach to subjects than formal learning, which still in some places is focused on performance and memorization rather than the retention of skills and know-how (Alekh et al., 2018). Informal and non-formal are not as validated as formal education (as in school, university and the like) in regards for future opportunities (Colardyn & Björnavold, 2004) but hold still opportunities for people to learn new skills and have an interesting hobby. The easiest way to understand what informal and non-formal education are, is to compare them to formal education which is familiar to most people. Formal education is authority recognized, has curricula, qualifications and in most cases lead to ratified diplomas or qualifications (Hofstein, Rosenfeld, 1996). The difference between informal/non-formal and formal science learning is not as clear when it comes to what can go on in schools. Like Walsh and Straits (2014) said, there can be informal learning elements in formal education, but Hofstein and Rosenfeld (1996) are not quite as sure. They say that the level of compulsion, structure and sequence can influence the way a situation lays in the informal/formal dichotomy. They also have a list of features for both types of learning which is pictured below in Table 1 by Hofstein and Rosenfeld (1996). The list of features is more than two decades old but hold many essential qualities that discern the formal from other types of education. The contents of Table 1 are used further along the thesis as a basis for a framework to look at the formality of the participant organizations.

Table 1. Features of Formal and Informal Science Learning (Hofstein & Rosenfeld, 1996)

Informal learning – field trips	**Formal learning – school**
Voluntary	Compulsory
Unstructured	Structured
Unsequenced	Sequenced
Nonassessed	Assessed
Unevaluated	Evaluated
Open-ended	Close-ended
Learner led	Teacher-led
Learner-centered	Teacher-centered
Out-of-school context	Classroom context
Non-curriculum-based	Curriculum-based
Many unintended outcomes	Fewer unintended outcomes
Less directly measurable outcomes	Empirically measured outcomes
Social intercourse	Solitary work
Nondirected or learner directed	Teacher directed

Hofstein and Rosenfeld suggest that the differences between informal/non-formal and formal education are not necessarily linear or straightforward but lie in the middle ground of the features listed in the Table 1 above. They tend to be shades of the features, not them as they are stated (Hofstein & Rosenfeld, 1996.)

2.1 The Question of Informal vs. Non-formal

The two concepts of informal and non-formal education are easily confused and most literature lumps them together to a one entity which is most usually called "Informal Learning" as it is closer to a daily used word. Nevertheless, in this thesis it is important to discern between these two since it does give more impact to the type of research that has been conducted. The categorization of non-formal and informal learning is used as per UNESCO (2012) has previously stated. Informal education is mostly what people learn in their day-to-day lives and has its basis on learning through experience. Non-formal learning is something that adds upon formal learning and can hold structures similar to it. Usually it is more flexible and produced by community, organizations or workplace centered agents (UNESCO, 2012.) Researchers such as Barker and Ansorge have used informal as a term to describe the learning happening in 4-H clubs (Barker & Ansorge, 2007) but since it displays the characteristics of non-formal education more clearly as per the UNESCO guidelines (2012), the paper of Barker and Ansorge (2007) will be considered to contribute to the study of non-formal education in the context of this study. For this thesis, it is the most applicable division between these two often mixed up concepts. Based on this, the observations have taken place in non-formal places of education.

Even though the word "technology" is used predominantly to describe the type of education that has been observed, STEM literature in general has been utilized as well since its context is similar excluding mathematics and science in broad terms even though they are important to the other letters of STEM which's definition comes from formal school subjects, its use outside of formal education is prevalent as well. Computer Science (CS) and Information Technology (IT) are used frequently throughout this thesis as well. The literature focusing on informal education still provides an important look into how education in STEM fields outside of the formal setting is provided in the Oulu area, as well as all around the world. This use of terminology does not elude to having these non-formal education opportunities formalized in the form of curricula. Even though it might be beneficial to introduce every child to these types of technologies and possibly future fields of interest, everything worth learning does not have to come from formal school (Eisenberg, 2013). If the opportunities are there and easily accessible (both location wise and monetarily), non-formal education might not democratize learning but it gives way for children and their caretakers to take other methods of learning into consideration when planning the education of their child and sometimes themselves.

Table 2 explains the differences and similarities of formal, non-formal and informal education as per Eshach (2007). It has many similarities to Table 1 where the subject was the characteristics of informal and formal education. Table 2 expands upon that to non-formal as well. Table 2 further supports the formal/non-formal/informal education styles and approaches to be gradients. Here non-formal and informal are clearly separated and provide a more in-depth look into the practices of non-formal education. Non-formal learning has more in common with formal education than with informal based on the level of structure.

Table 2. Differences between formal, non-formal and informal learning (Eshach, p. 174, 2007)

Formal	**Non-formal**	**Informal**
Usually at school	At institution out of school	Everywhere
May be repressive	Usually supportive	Supportive
Structured	Structured	Unstructured

Usually prearranged	Usually prearranged	Spontaneous
Motivation is typically more extrinsic	Motivation may be extrinsic but is typically more intrinsic	Motivation is mainly intrinsic
Compulsory	Usually voluntary	Voluntary
Teacher-led	May be guide or teacher-led	Usually learner-led
Learning is evaluated	Learning is usually not evaluated	Learning is not evaluated
Sequential	Typically non-sequential	Non-sequential

Eshach (2007) has another good visualization about the differences between non-formal and informal education. This is depicted in Figure 1, where the different experiences of out-of-school science learning are divided into two camps: non-formal and informal science learning. The most notable difference this figure has to the tables 1 and 2 above besides the different format of conveying information is the heavy emphasis on the place the learning takes place in. The summary of the Figure 1 is that non-formal learning happens in places visited occasionally and informal learning takes place in places within day-to-day routines.

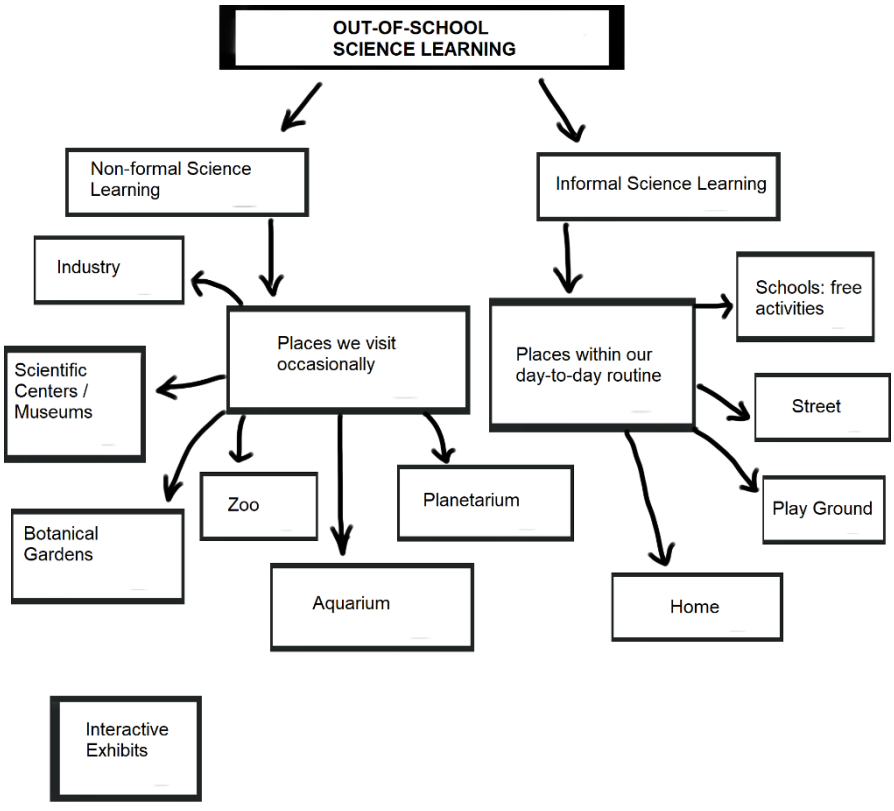


Figure 1. Categorizations of properties of out-of-school learning (Eshach, p. 174, 2007)

From this point on, the thesis will use the concept of "non-formal education and learning" as the best way to describe the observations and interviews done for this thesis. The definition is based on the literature cited above.

2.2 Locations of Non-formal Technology Education

Non-formal (and literature of informal) education has shown to be an effective way to advance science learning (Hoffstein, Rosenfeld, 1996). Hofstein and Rosenfeld in 1996 mention zoos, science museums, science media and science youth programs as such environments, more recent sources like Fischback and Lee (2017), Cain and Lee (2016) and Alekh et al. (2018) talk about FabLabs, Maker communities, workshops and after-school clubs. Typically, informal learning happens outside of school (the building and the time) as per the definitions stated above (Hofstein, Rosenfeld, 1996). It is possible to hold informal/non-formal learning events in "formal" settings as well, Walsh and Straits (2014) write about Informal Science Institutions (ISI) and how formal schools can have field days or excursions to inspire children more. They also list multiple institutions that can have physical locations for people to attend that can also work as informal places of learning. Those are science centers, aquariums, libraries, botanical gardens, parks, planetariums and farms. ISIs can also include businesses, organizations and government agencies (Walsh & Straits, 2014.) Based on the literature, they can be characterized as either "unintentional learning", such as museums, zoos and aquariums, because the learning happening in these situations is not necessarily instructed, whereas after-school clubs, 4-H and some Maker Communities can be considered to provide "intentional learning" as they have instructors on site (COM'n'PLAY SCIENCE, 2017). This division is not concrete but something that could be picked up in the literature.

A study by Weibert, Sprenger, Randall and Wulf in 2016 focused on intercultural computer clubs in Germany. The Come_IN clubs were mainly held in schools in intercultural neighborhoods and function on the basis of communality, creativity and local usefulness for problems such as gender issues or language barriers. The strive for togetherness and integration of ages, genders and ethnicities is apparent in the clubs' mission (Weibert et al., 2016.) There are places such as the Computer Clubhouse that are free for children to attend. They provide a number of possibilities such as video gaming and photo editing on Photoshop (Maloney, Peppler, Kafai, Resnick & Rusk, 2008). 4-H clubs have curriculum for robotics education in the state of Nebraska in the United States as of 2005 (Barker & Ansorge, 2007). Summer camps are a visible part of the non-formal landscape of computer science education (Sullivan, 2008). Some makerspaces provide their own afterschool programs to school aged children, such as the community makerspace in Northern Utah (Fischback & Lee, 2017). Makerspaces are known to host researchers with their ideas as well. Workshops led by researchers to know how children operate in different situations while learning something is a great opportunity for all parties included (Alekh et al., 2018). Makerspaces and FabLabs can employ "drop-in" practices to make entering the space and possibly commencing in Maker -related activities as easy as possible for children (Bar-El & Zimmerman, 2016). Competitions seem like places where one comes to profess their skills not to learn but there is literature about learning done in them. Usually to achieve this, the people attending are given the same materials and should have similar backgrounds. The competition can work as an exam (Grover, Krishnan & Khanbaghi, 2014) or as the whole program (Stewart & Jordan, 2017). Even though some museums, zoos, makerspaces and aquariums are used by organizations specialized in education, the institutions themselves can provide non-formal learning as well (Eshach, 2007). Museums as places of informal and non-formal learning usually rely on having exhibits as a means to communicate and organize (Horn, Solovey, Crouser & Jacob, 2009). They can have specific makerspaces in them as well like the Children's Museum of Pittsburgh's MAKESHOP (Wardrip & Brahms, 2015).

2.3 Procedures of Non-formal Technology Education

Humans are fickle creatures. We need something to pour our energy into to feel fulfilled and the same happens with hobbies for children and teenagers. For us to understand how and why children and teenagers would have fun in non-formal learning situations, it is important to know what they do in the clubs and after-school programs they take part in; some people just prefer different activities than others and get more stimulus out of doing things differently (Cain & Lee, 2016). Since non-formal education does not have a singular purpose or a set of features (Hofstein & Rosenfeld, 1996), it is important to know in which ways the different instances of non-formal learning manage to give the attendees the knowledge, know-how or skill they have come to look for.

2.3.1 Tasks and Time Spent in Clubs

How time gets spent in non-formal education is a topic that does not have a lot of research done about but Fischback and Lee in 2017 took a look at how time was spent in a makerspace afterschool club. They noticed that while there are overarching themes of activities that different types of projects utilize, the time taken by material acquisition and deposition are the largest across different activities and can be seen in most Maker-related activities. Tasks should be in small enough chunks for attendees to understand and they should be enticed to complete every check point if there are any (Alekh et al., 2018) but the idea of the concept should still travel through the medium of education. This is a bit surprising but in the study by Merkouris, Chorianopoulos and Kameas (2017), they streamlined the process quite a bit by attaching the LEDs into the materials beforehand. This could lead to children not having much fun with the technology since the practice mainly consists of attaching conductive thread and switches. The duration for the task was 10-15 minutes so it is understandable that it would need some condensation, but it would have been interesting to see how children reacted to the whole Arduino LilyBad concept. It is not as high of an immediate gratification, but it has the potential to surprise positively. Some learning activities are not about teaching the attendees about how to make or program the subject of the day's lesson but about general interests, functionalities, science and real-life applications of the subject (Alekh et al., 2018.) It can help children ground their interests in everyday examples which makes them more related to the topic.

Online community platforms provide support for networking and communication between participants. In a study they have been documented as being used for photo album creation, adding friends and searching for projects (Weibert et al., 2016). Fischback and Lee (2017) observed an afterschool Maker Program and studied how the time got spent. They also provide a crucial look into what types of activities take place in these programs and categorized them based on their function. The observed afterschool club provided three different projects that the children could choose, and they all needed different types of technologies to accomplish. They were a LED incorporated cardboard box (technologies used: circuits, soldering and microcontroller programming), model rocket (laser cutting vinyl for creative decorations, finding out the most effective rocket fuel) and lanterns (laser cutting, RGB lights) (Fischback & Lee, 2017.) These three projects, especially the card box one, are very similar to the ones observed in Oulu so the impact of Fischback and Lee's study (2017) on this thesis is remarkable. Children typically make construction kit parts, charms, bracelets etc. and for example customized souvenirs from museums (Eisenberg, 2013). Although educators instruct in lieu of formal education, some methods are different. The educators in non-formal situations might prefer a discussion about "what went wrong" or "what was successful rather than giving

the participants the solid answers or correct ways to work immediately (Alekh et al., 2018). For a group to work well together, there might be some participants that act as "glue" for the social situation keeping people together. The collaborative aspect of this type of cooperation can be obvious to some people (Weibert et al., 2016).

2.3.2 Motivation of Attendees

It is important to keep learners motivated so that they can keep on learning (Francis, 2013). There are multiple reasons to have a child attend non-formal education. Giving children a hobby that they could be interested in is probably the first idea that comes to a parent's or guardian's mind but there are other reasons including the learning of science literacy skills (Sullivan, 2008). Through motivation, play can lead to learning (Draper, 1999). Motivation is important for learners to feel successful (Francis, 2013). Aesthetics can be very important for young people when given the freedom to do what they want with the outward appearance of their project (Alekh et al., 2018). Children can be provided with tools to express their creativity in a more technical way. The Pleo robotic dinosaur is programmable and gives children the opportunity to make stories in their own drawn landscapes with stories they have come up with (Ryokai, Lee & Breitbart, 2009). Based on the observations and interviews, creativity and aesthetics are not a large part of the experience of non-formal education, but it does give some motivation to perform tasks to their completion. Motivation of students is extremely important as well. The motivations for the attendees might be more intrinsic than in formal education as in the motivation to attend comes from within the attendee, not from outside pressures such as national school curricula or pressure from parents (Eshach, 2007.)

2.3.3 Roles

There are a lot of different types of roles in informal education. The educators are the most noticeable one as they have many responsibilities and a lot of visibility. Educators also come from numerous backgrounds, in Steward and Jordan's case study, the two instructors were volunteers from an electronics company (Stewart & Jordan, 2016). Some clubs also have peer guidance for participants in the form of previous years' attendees as team leaders (Stewart & Jordan, 2016). Teen mentors are one viable option for instructors, like in the scouts (Bar-El & Zimmerman, 2016). The teenaged mentors might not be capable of handling every need the participants have, and it is important to find the right balance between too little and too much instructing (Bar-El & Zimmerman, 2016). Some clubs and programs also invite children's parents to take the roles of educators or mentors to the technologies and methods used. In Fischback & Lee's study (2017) that was the case. Parents were assigned the roles of educators at the side of the employees of the makerspace.

Experts who teach in non-formal science education are reportedly more likely to be male (by 56,3 %, 39,8 % female, 3,9 % prefer not to say or are neither) and only around a sixth do that work full-time (Tisza et al., 2019a). The role of educators holds many different tasks. Instructing is the most obvious one and the way that they see the role, can influence how participants learn. Educators are called different names in different places. Teachers, instructors and some have more descriptive names such as Teaching Artist (Wardrip & Brahms, 2015). Some participants feel that having a closer relationship (by way of peer ship or having similar interests) can help with having a connection to their task and find it easier to ask for advice (Bar-El & Zimmerman, 2016). That is most applicable when the educator is interested in their own craft and have passion towards it (Francis, 2013). Educators can take their subject too seriously to allow a relaxed atmosphere (Garner, 2006) which is one of the defining features of non-formal education (Hofstein, Rosenfeld,

1996). Also, some participants prefer a more unstructured style of education (Bar-El & Zimmerman, 2016).

2.3.4 Challenges in Non-formal Education

There are multiple different challenges in non-formal learning that are characteristically descriptive of its practices as well as those that are similar with those of formal education. One major challenge is that there is no guaranty of the level of knowledge or know-how the participants have in the subject they are studying in non-formal education. Stewart and Jordan recorded in their 2016 case study the differences of robotics and programming knowledge in the participants' small teams. The need to advertise the club or activity is also inherent in some of their designs. If it is catered to an age group or level of knowledge, there will be need for new students time to time (Weibert et al., 2016). There are problems with finding the best suitable programs for your child as well as to realize the informal alternatives for some very costly clubs (DiSalvo, Reid & Roshan, 2014). The fact that some clubs and programs can cost money is a deterrent for less wealthy parents and guardians to provide their child with the "hobbies" that they would prefer (Maloney, Rusk, Burd, Silverman, Kafai, & Resnick, 2004). Some difficulties can be handled a lot differently than in formal education, for example behavior problems. If someone continues to misbehave, they can be thrown out of a club (Weibert et al., 2016) unlike in formal education where it is considered neglect and possibly a criminal offense. The educators can think that the "learner centrism" does not allow them to teach by example, just by asking questions and guiding from the side lines. Instructors can be given guidelines that mention that the participants should do all of the work and adults should help them find answers, not give them. This leads to the educators to consider themselves as guides, rule-enforcers and question-answerers (Stewart & Jordan, 2016.) Nonetheless, even in non-formal settings, teachers retain a level of authority (Weibert et al. 2016). Since the structure is more loose or non-existent, children have more room to fail, which is not necessarily a bad thing. Failure in an instructed way can lead to even more knowledge since you have to figure out what has gone wrong and improve your design or product in other ways (Alekh et al., 2018).

2.4 Technologies and Their Uses in the Clubs in Oulu

Education has come a long way from stone slates and memorizing the bible to learn how to read to today's system where more and more students use materials that are given to them in a virtual form. Laptops in lecture halls are not the only sight of learners in formal education using technology, the Finnish matriculation exams are already held with computers to mention one occasion. There are multiple different technologies used to teach children formally, non-formally and informally about technology and in the following subchapters the ones that were the most used in the clubs observed are introduced. For this thesis to reflect the HCI field, it is important to know of the different technologies used as they have an impact on the procedure and fun in the clubs. Below the technologies are mentioned in **bold** for clarity during their first mention in the text. The inclusion of these technologies in the text helps to get a feel for the different vehicles of education to the attendees and how they relate to the landscape of non-formal education, if there is literature about that. New technologies are developed and the field of IT/CS education is changing and moving constantly, and those responsible are always trying to find new and improved ways of teaching children. One new thing that has stated its claim in public consciousness is wearable technology such as smart watches and virtual and augmented reality glasses. For us adults they might seem intriguing, but they do not interest children any more than the "traditional" resources used to teach programming or

robotics (Merkouris, Chorianopoulos & Kameas, 2017.) Non-formal and informal education are dependent of technology in different ways, but the materials used to let children experiment with technology range from Play-Doh to Arduino (Papavlasopoulou, Giannakos & Jaccheri, 2017).

2.4.1 Programming Clubs

Android Studio is an IDE designed for application development for Android devices. Besides the programming environment, Android studio provides an emulator, testing tools and frameworks and code examples to name a few (Android Studio, 2019.) **Freecodecamp.org** is a nonprofit community that provides aspirant web developers free coding challenges to better their skills. The web site is totally free and it relies on its donors to keep the site running (Freecodecamp.org, read 28.7.2019.)

Scratch is a well-used tool for teaching children programming, (Weibert et al., 2016) the most frequently used even (Papavlasopoulou et al., 2017). It is a free environment online where people (mostly children) can program interactive stories and games for others to enjoy. It is a project by MIT's (Massachusetts Institute of Technology) Lifelong Kindergarten Group. Scratch also supports multiple different languages (including Finnish) and uses its own programming language which is based on coding blocks that the programmer can move to their positions (Scratch, 2019) but the new Scratch 3.0 uses JavaScript as its implementation language. Scratch has been built by using Googles Blockly technologies and by extending them (Scratch, 2019). It is designed to be highly interactive and to evoke thoughts about tinkering (Resnick et al., 2009). The most notable concepts of programming with Scratch are Sprites, Scripts, Events, Signals and Custom Blocks (Aivaloglou & Hermans, 2016). Since Scratch is developed and up kept by MIT, there's a lot of literature about its conception and development. The motives behind its creation lays in that there are so little opportunities for disenfranchised young people and children to learn programming for free with basic equipment (Maloney et al., 2004). Further on, the goal of Scratch expanded to nurture a future generation of creative, systematic people who can use programming to express their ideas (Resnick et al., 2009).

Scratch has a social side as well. The site encourages pudding programmers the "Share" their creations and to "Love It?" others' projects. From sharing their projects, the programmer can find their handy work on the front page of Scratch under "Newest Projects" and others interested will get to try it out (Resnick et al., 2009.) From the around 250 000 Scratch projects Aivaloglou and Hermans analyzed in their study, around 40 % had some conditionals and other basic to higher level programming statements. 8 % held complex procedures (Aivaloglou & Hermans, 2016.) There are around 43 million shared Scratch projects as of July 25th of 2019 (Scratch Statistics, 2019) and it has been dubbed the YouTube of interactive media (Resnick et al., 2009). The most noticeable positive thing about learning programming with Scratch or other visually aided programming languages is that the meticulous work of keeping the syntax nice and tidy is not an issue anymore (Malan & Leitner, 2007). Even the most simple and well-known first step to programming the "Hello World!" task needs multiple other steps in most languages than "print (Hello World!)". The syntax can hinder and almost discourage learners from learning coding. Even if the programmers using Scratch do not see the code in itself necessarily, they do get a sense of how the different parts of the programming language work (Malan & Leitner, 2007). It can also be likened to art as a school subject by kids more than to programming itself, even though the participating children did learn about programming terminology and functionalities (Maloney et al, 2008). The division between non-formal/informal and formal education comes to play here as well. Scratch is considered an informal tool of education (Maloney et al., 2004) but there are precedents

of it being used in non-formal education as well (Malan & Leitner, 2007) like in the observed instances for this thesis.

Unity 3D is a game engine that is free for educational purposes. Even though it is used on bigger projects (for example indie sweetheart Cuphead (Unity 3D Made With, 2019)) it provides children 10 and up the tools to make their first game. A project that they propose and give tutorials for is Space Chicken (Unity 3D Space Chicken, 2019). During a study on how Unity performs as a tool for teaching game development in formal education, it performs considerably better than, for example, game application development tools to aid in the completion of a project (Dickson, 2015.) With game development-oriented learning (and why not others) the easiest tasks with the quickest rewards might not be the best alternative (Dickson, 2015). The research this was found in was conducted on college students, so it does not completely apply to the age group of 8-19 that was observed in this thesis but it does give a look into how different approaches to learning through game development compare. Unity 3D proved to be the most easily accessible and had the lowest learning curve out of the quite freely available 3D game engines between XNA and Unreal (Dickson, 2015.) Game programming can influence attitudes and confidence positively as well (Denner, Campe & Werner, 2019). **Tic-80** is a "fantasy computer" that allows programmers to make mini retro games (Tic-80 Github, 2019). It functions like an "old timey computer" with a command prompt like set up, code editor and sprite, sfx (special effects, mainly sounds) and map editors. It is an open source project by Filippo Rivato, Fred Bednarski, Al Rado, Trevor Martin, MonstersGoBoom, Matheus Lessa, CliffsDover, Frantisek Jahoda, Guilherme Medeiros, Andrei Rudenko, Phil Hagelberg and Rob Loach.

As can be seen, game programming is a popular way to teach computer science to children. There are six main problems-solving skills that people most usually have and can develop in computer science. *(1) Formulating problems in a way that enables us to use a computer and other tools to help solve them (2) Logically organizing and analyzing data (3) Representing data through abstractions such as models and simulations (4) Automating solutions through algorithmic thinking (a series of ordered steps) (5) Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources (6) Generalizing and transferring this problem-solving process to a wide variety of problems*. (Denner et al., 2019, p. 19:22) Through game programming children can develop their algorithmic thinking and problem-solving abilities. One major thing that is also noticeable is the influence of game programming on the attitudes children and teens can have for computer science (Denner et al., 2019.) In general, children programming games increases their know-how on coding but there has not been evidence that game development aids in the progressing of other IT or computer science related fields. More than programming know-how, game design and programming increases children's engagement in it and there seems to be no evidence for pedagogical methods to influence the engagement negatively (Denner et al., 2019.)

2.4.2 Robotics Clubs

In robotics clubs, there are usually many different opportunities and resources available. Some of them go hand in hand with programming and maker related activities, others are more specifically tailored to robotics education (Merkouris et al., 2017). LEGO can be considered a household name for introducing children to robotics or at the very least mechanics. In the case study by Stewart and Jordan (2016) they observe a 9 year-old's way through an after-school robotics club where they used **LEGO Mindstorms** kits to familiarize the participants with robotics and prepare them for a LEGO competition that

in its mission statement mentions fun as one of their primary goals. LEGO Mindstorms is a product or kit by the LEGO Company directed more towards education and hands-on experience. It consists mainly of a motor, other LEGO blocks and a "smart brick" that is known as the EV3 that is programmable and based on what sensors are attached, could do basic functions based on that. It also comes with its own programming environment that uses a block-based language and that LEGO says can provide a more creative and interactive learning (LEGO, 2019.) Without the parts to move, it does not provide as much enticement as possible, so the Mindstorms kit comes with some technical pieces, wheels and such. The LEGO Company produces technical kits for younger learners as well that can help children learn about machines and mechanisms. They can be powered or not (LEGO, 2019.) Learning programming and other robotics related skills with LEGO Mindstorms is more preferable than with Scratch. Children express more positive emotions when playing with Legos than from programming with Scratch (Merkouris et al., 2017.)

Arduinos are considered a low-cost tool for multiple purposes. They are used in education quite frequently due to their inexpensiveness and versatility (Grover, Krishnan & Khanbaghi, 2014.) Arduino uses its own programming language and an IDE that provides an easy way for beginners to prototype code. It is also open source, which means that there is lots of documentation online (Arduino, 2019.) **The micro:bit** is a product of BBC for the need of inexpensive programmable device to teach computer science to children in the British formal education. Children between 11 and 12 were given micro:bits in 2015 which amounted to around 800 000 units (Sentance, Waite, Hodges, MacLeod & Yeomans, 2017.) The micro:bit has a 5x5 LED screen, two buttons, reset button, accelerometer, compass, thermometer, light sensor, processor, radio & Bluetooth antenna as well as sockets and connectors for accessories (micro:bit Features, 2019.) The different editors allow users to program with either a block based language, JavaScript or with Python (micro:bit Code, 2019). Micro:bit has a low entry point and due to its size and interactivity (by having a screen), it feels more "real" to users. It has also been documented to be positive learning experience (Sentance et al., 2017.) Tangibility all around can improve children's experiences with computer science learning (Sentence et al., 2017). Tangibility in the series of observations done for this thesis relates to the children having something in their hands and seeing the results "physically" which is mentioned in the interviews further along the thesis. Storytelling can be a powerful tool in piquing the interest of younger children (Ryokai et al., 2009). The writers of the study did not state so, but from their reporting and other papers done on the subject of fun, interest and engagement (Cain & Lee, 2016), it would implicate that the children who participated in Ryokai, Lee and Breitbart's study (2009) experienced positive feelings and possibly even fun while experimenting with a dinosaur robot and telling a story through it. The performance of the task was described as "*The children moved fluidly between drawing cards, programming the cards, playing back the completed cards […] Having the physical cards with their drawing as representations of programmed interactions between Pleo and themselves seemed to make the manipulation easier*." (Ryokai et al., 2009, p. 25)

2.4.3 Maker Culture Related Activities

Even though Maker Culture is a relatively new area of interest in the scheme of non-formal education, there have been multiple strides made in regard to how and what children and young people should be taught to understand the methods and nature of it. Its rise can be compared to the way personal computing arrived in our homes at varying times (Eisenberg, 2013). First the big companies and field enthusiasts got their hands on them (Eisenberg, 2013), now I could walk into a nearby electronics shop and pick a 3D

printer of the shelf into my home for less than 500 Euros. This spread of technology and interest in it has provided us with a massive amount of opportunities to learn about how these technologies get thought outside of the formal school setting. Eisenberg is regarded as one of the visionaries in CCI (Child-Computer Interaction) and has proposed many new ways of teaching children about Making. In his 2013 paper he talks about how Making can be further developed to suit the needs of younger users since in today's marketplace, most printers and cutters are geared towards older users. Fischback and Lee (2017) describe the different activities happening in an after-school Maker program. They categorized the activities as assemble, creative construction, tinkering, instruction, material acquisition, material storage and novel experiences. They are a good representation of the technical activities found in Maker programs but for this thesis they lack the "fun" aspect, as in social interactions, joking and/or playing with their creations. Design principles and object interaction can also be taught to children while they engage in maker related activities (Alekh et al., 2018.)

Eisenberg (2013) lists five technical challenges in 3D printing that should be solved by the people who design 3D printing activities to children. They are *"(a) expanding the range of physical media available for printing, (b) incorporating ideas derived from ''pick-and-place'' mechanisms into 3D printing, (c) exploring methods for creating portable and ubiquitous printing devices, (d) creating tools for hand-customization and finishing of tangible printed objects, and (e) devising software techniques for specifying, altering, and combining 3D elements in the context of printing*." (Eisenberg, 2013, p. 8). In a 2015 short paper by Iversen, Smith, Blikstein, Katterfeldt and Read they discuss how the problems stated by Eisenberg have yet to be solved. Not every maker activity is closely related to 3D printing and/or laser cutting. Some researchers call construction from pre-made parts or readily available materials "Maker" as well. These resources include engineering parts such as different sheets, valves and pumps as well as "every-day" items like corks and tapes (Alekh et al., 2018.)

Fusion 360 is a modelling software that can be utilized for 3D printing. It is made by Autodesk, who are experts in the field and have previously produced the Autocad 3D modelling software that most people interested in engineering have heard about. Fusion 360 supports multiple different modelling techniques such as mesh and parametric modelling (Fusion 360, 2019.) **Inkscape** is a vector graphics illustrator used in to make designs into readable forms for laser cutters as well as multiple other things. Inkscape uses scalable vector graphics and is open source (Inkscape, 2019) Since robotics and maker culture are a little entwined in the realm of non-formal STEM education, most of these descriptions could apply to be used in maker-related activities. The 3D printer most used in the Koodikärpät-kerho was the **RAISE3D Pro2** that could use multiple different filaments (PLA / ABS / HIPS / PC / TPU / TPE / NYLON / PETG / ASA / PP /PVA / Glass Fiber Infused / Carbon Fiber Infused / Metal Fill / Wood Fill) in different colors. It also had a touch screen interface on the printer itself that showed, among other things, how far along the printing was (RAISE3D, 2019.) The laser cutters in the University of Oulu FabLab were both from the **Epilog Laser**'s Fusion line. They were different sizes, but their functionalities were essentially identical. They can cut numerous different materials and the settings are customizable so a lot of design freedom could be achieved (Epilog, 2019.) In Table 3 there is a small recap of the different technologies observed to be used as well as what they are and how they are generally used in non-formal education settings based on the sources above.

Table 3. Compilation of the different technologies used.

Technology	Classification	Utilization	Club used in
Android Studio	IDE /Software	Programming Android applications	Koodikärpät-kerho, Android development
Freecodecamp.org	Community/ informal web development learning tool/web site	Teaches web development	Käädikärpät-kerho, Web Development
Scratch	Web site / informal game development tool	Storytelling via games, game programming	Tiedekoulu, Programming
Unity 3D	Game engine / All-in-one editor	Game programming	Koodikärpät-kerho, Game development
Tic-80	Game engine	Game programming	Koodikärpät-kerho, Game development
LEGO Mindstorms	Building "Toy"	Mechanics instruction	Tiedekoulu, Robotics
Arduinos	Multipurpose tool / development board	Programmed to command other electronics	Koodikärpät-kerho, Robotics
Arduino IDE	IDE with own language	IDE to program Arduinos	Koodikärpät-kerho, Robotics
Micro:bit	Programmable device with sensors	Programmed to use its many qualities.	Tiedekoulu, Robotics
Micro:bit IDE	IDE with Java or block-based language	IDE to program micro:bit	Tiedekoulu, Robotics
Fusion 360	Modeling software	Modeling 3D models for printing	Koodikärpät-kerho, Robotics
Inkscape	Vector graphics illustrator	Modeling 2D models for laser cutting	Koodikärpät-kerho, Robotics
RAISE3D Pro2	3D printer	3D printing	Koodikärpät-kerho, Robotics
Epilog Laser	Laser cutter	Laser cutting	Koodikärpät-kerho, Robotics

As can be seen, the use of technology is wide spread in the clubs observed. Of course the name of this thesis implies that technology is in the focus and in a way it is since the clubs providing the observed non-formal education were about programming and robotics.

2.5 People Finding Hobbies and Clubs Finding Participants

It is crucial for non-formal educative practices to find enough suitable participants be they after-school clubs or services provided by museums or zoos. There are a lot of ways to make themselves known and to accept attendees. Some have open doors (Weibert et al., 2016) and others might have procedures to decrease the number of attendants (Stewart &

Jordan, 2016). With after-school activities it is quite easy to understand that the participants are usually school children that got the info about the activity from school (Stewart & Jordan, 2016) but other instances might be a bit tougher to realize. For the case study by Stewart and Jordan in 2016, they observed an after-school club that admitted participants by holding try-out sessions where children solved robotics-based missions and their academic performance. Some hold registrations ahead of time for an expected amount of time (Fischback & Lee, 2017). The Come_IN clubs initially wanted for attendees to attend together with their parents but this was scrapped further on because some parents could not participate in the frequency it would be most useful to their children (Weibert et al., 2016).

There is a major problem underlying in the way that non-formal STEM education finds its participants: the participants need to find them first. DiSalvo, Reid and Roshan (2014) did a study based on the findings Google could give their study participants about non-formal computer science education in a financially depressed neighborhood in Atlanta, Georgia in the US. They found that it was extremely hard to find a place for young people to take part in non-formal STEM education so they widened their scope location wise since they expected it to be more of a problem in the Atlanta region. They found that the biggest cities of the country provide the most opportunities (DiSalvo, Reid & Roshan, 2014.) One surprising thing in the experiment was that none of the largest, most prevalent sites for informal learning (such as Scratch or Udacity) did not come up when searching for informal/non-formal computer science education related terms (DiSalvo et al., 2014). It is quite apparent that the people who have a child interested in computers and do not themselves have a grasp on the world of information technology, might have to miss out on these opportunities. The writers state that the same people might not even realize that there are free alternatives to expensive camps for the same purposes online (DiSalvo et al., 2014).

2.6 Summary and Framework of Non-formal Education

Education can mean different things to different people, the same goes for non-formal and the linearity of the formal/non-formal/informal trichotomy as well. From the literature it is apparent that the concept of non-formal education is not clear and for the purpose of this thesis a framework that is a synthesis reliant on the UNESCO (2012) definitions for non-formality and the different attributes and qualities of it given by Alekh et al. (2018), Eshach (2007), Hofstein and Rosenfeld (1996) and UNESCO (2012). Table 3 presents this synthesis that has been modernized and made to fit the Finnish education system better (Finnish Curriculum of Basic Education, 2014). Since the paper by Hofstein and Rosenfeld (1996) does not completely correspond to the view of formal education in Finland in the year 2019, "formal learning is teacher centered" and "formal learning is solitary work" have been included in "pace" and "freedom of socialness" features in the table below. They also correspond to the new Finnish Curriculum of Basic Education (2014) which uses language such as children are to be encouraged in changing situations to act flexibly and creatively and "*The basis of choosing work habits are goals set for teaching and learning as well as the students' needs, prerequisites and interests*" (Finnish Curriculum of Basic Education, p. 30, 2014). Also, "Teacher directed", "teacher led", "Curriculum-based" and "teacher centered" have been allocated as pace, which describes who is in charge of the pace of education and generally keeps track of how children progress. This also reflects Eshach's (2007) Table 2 of differences between formal, non-formal and informal education where the only part about teachers was about how the education was led.

Table 4. Compiled and modernized qualities of formal, non-formal and informal education.

Feature	Formal	Non-formal	Informal
Level of voluntariness	Compulsory	Usually voluntary	Voluntary
Structure	Very structured (nation/area vide)	Loosely structured	Unstructured
Sequencings	Sequenced	Typically non-sequential	Non-sequenced
Level of assistance	Assisted	Assisted	Unassisted
Evaluation	Evaluated	Usually not evaluated	Not evaluated
Finalization	Close-ended	Usually open-ended	Open-ended
Pace	Teacher led	Usually Learner led	Learner led
Motivation	Extrinsic	Extrinsic/intrinsic	Intrinsic
Context	School	Places that are visited occasionally	Places within day-to-day routine
Spontaneity	Prearranged	Usually prearranged	Spontaneous
Freedom	Maybe repressive	Usually supportive	Supportive
Freedom of social interaction	Restrictive	Usually supportive	Supportive
Intentionality of outcomes	Intentional	Less intentional	Unintentional
Measurability	Empirically measurable	Less directly measurable	Less directly measurable
Room to fail	Limited	Usually yes	Yes
Flexibility	Rigid	Usually flexible	Flexible

For the finalization and intentionality of outcomes there are movements towards having standards in non-formal and informal education to have comparability between the European countries (Colardyn & Bjornavold, 2004).

3. The Manifestation of Fun

Empowerment and engagement are the strongest sources of joy as the feeling of discovery can bring prolonged interest and even a feeling of fun (Nielsen, 2003). Fun is something that definitely belongs to a child's world (Read, MacFarlane & Casey, 2002) and as such, should be studied in many ways. In the subject of learning, negative emotions and low satisfaction or low effectiveness happen simultaneously from the same prompt and fun is generally considered a positive emotion which leads to the assumption that it would entail higher satisfaction and effectiveness (Sharma, Papavlasopoulou & Giannakos, 2019). Sharma, Papavlasopoulou and Giannakos (2019) proved that other positive emotions like happiness could get those results. They are not sure though if the happiness comes from the task or the level of comfort a person has performing tasks familiar to them (Sharma et al., 2019). Carroll and Thomas (1988) concluded that uncertainty can be fun as well, it just should be in the appropriate context. "*Introducing uncertainty into a flight simulator game probably makes it more enjoyable. Introducing uncertainty into a text editor or spreadsheet may or may not make it more enjoyable.*" (Carroll & Thomas, 1988, p. 23)

This chapter, its paragraphs and literature are found and built to support the observations and interviews discussed later on in the thesis.

3.1 Clarifying the Concept of Fun

The elusive concept of fun. Is it happiness and laughter or humor and enjoyment? Is fun an emotion or an experience? There is no one definitive answer since like beauty, fun is in the eyes (and ears and probably other senses as well) of the beholder. There is literature from multiple decades about what fun can be and how it can influence different things. but there is a lack of definition for the terminology. Enjoyment, pleasure, fun and attraction are widely used to mean the same expression (Blythe & Hassenzahl, 2003) Easy tasks can be more fun than difficult ones in the sense that there was no irritation or teeth-grinding related to performing them (Carroll & Thomas, 1988). Fun is mixed very easily with pleasure, attraction and enjoyment (Blythe & Hassenzahl, 2003). That is why it is important to know semantically what these other definitions mean since they could, or could not, be related to fun in the way this thesis defines it and how fun in non-formal education presents itself. Enjoyment is used to describe play (Hanna, Neapolitan & Risden, 2004; Read & MacFarlane, 2006), to be a reward (Eshack, 2006), in learning (Sim, Stuart & Read & MacFarlane, 2006) and as hobbies (Eshack, 2006). Enjoyableness should come from within the design and it should not be a glued on property (Overbeeke, Djajadiningrat, Hummels, Wensveen & Frens, 2003). Excitement is easily equated to fun (Stewart & Jordan, 2016). Excitement can also mask dissatisfaction. It is also possible for learners to feel dissatisfied, bored or "not good" if they have participated without learning (Stewart & Jordan, 2016). Cain and Lee (2016) studied engagement with electrodermal technology. Engagement is a valuable metric to understand what is enjoyable for children since it is an indicator to interest. They found that their two test subjects did have differences in engagement patterns which suggests that not all people find the same activities interesting (Cain & Lee, 2016.) Humor is something that is fun, but is fun humor? That is up to debate but for this thesis sake, humor is one quality of fun since it provides positive feelings (Sharma et al., 2019), has similar outward expressions as fun (COM'n'PLAY SCIENCE, 2019) and it can function as a cognitive break (Berk, 1996).

3.2 Different Forms of Fun

From the literature, many ways to have fun arose, even in papers where the fun aspect was not in the focus (Alekh et al, 2018). In the paper by Alekh et al. (2018), the focus was on Constructionist learning and Maker related activities but they mentioned that the activities were designed to be fun, even though it was not a central theme. The interest of using fun to entice people to do certain activities is not that much of a novel idea, but a very powerful one. Based on empirical data gathered during the observations and interviews in this thesis, as well as literature, three different forms of fun could be found in the setting of non-formal education. These are explored in more depth in the following chapters but to familiarize the concepts, the different presentations are "Pedagogical Fun", "Fun in Doing" and "Social Fun". The literature for the first two is present in multitudes, there were dedicated sources for each in applicable fields but for social fun, the existence of previous literature in even adjacent fields is dubious.

3.2.1 Pedagogical Fun

Even though school and fun are usually in the same sentence only with the words "is not" in the middle, fun has been considered to be pedagogically interesting since the 90's (Draper, 1999). There must have been fun in (formal) classrooms before that but scientifically it has picked up a little recently. Humor can be used as an educational tool as well (Berk, 1996). If you are experiencing positive emotions, it is more likely that you will be doing what you are doing for longer periods of time (Sharma et al., 2019). Humor can be used as a communication tool to alleviate anxiousness and to improve learning abilities (Berk, 1996). It can create a more relaxed atmosphere and genuine enjoyment which lead to a cognitive break for students which leads them to assimilate what they have learned more easily (Garner, 2006). In order for teaching to be effective and for the learners to internalize the subject, it is important for them to think about learning in a positive way, which can be eased by having a laugh or even a snicker (Berk, 1996).

Berk (1996) used a list of humor tactics to use when the goal is the reduction of anxiousness in a class room: *"(a) humorous material on syllabi, (b) opening jokes, (c) skits/ dramatizations, (d) in-class spontaneous humor, (e) in-class humorous examples, (f) humorous problem sets, (g) Jeopardy! ™ -type reviews for exams, and (h) humorous material on exams.*" (Berk, 1996, p. 76) Jeopardy is a TV game show where answers are given on a board and the competitors have to guess the question. The "Ability to Learn" subscale consisted of b, c, d, e, f and g from the list above, the "Perform Your Best" scale of d, f g, h and one other of "*humorous material on exams, and the overall effectiveness item*". They added two tactics after three years, which are "*humorous material on handout covers* and *in-class humorous questions*" (Berk, 1996, p. 76). They found that all of the humorous tactics above were deemed either very effective or extremely effective. (Berk, 1996) All of these tactics cannot be implemented in non-formal education since it does not usually have tests (Hofstein & Rosenfeld, 1996) but most are well fitting in such situations. The non-formality can even enhance joking and playing games. Berk (1996) still gives a warning: educators should not be entertainers and should only employ low risk humor techniques. Humor in formal class rooms is a straightforward way of increasing the retention of information (Garner, 2006) and the motivation of the students (Francis, 2013). Humor can also close the bridge between students and educators, it also gives the students the impression that the educator has went the extra mile in their background work (Garner, 2006). Different pedagogical tactics such as showing previews and different sorts of videos into what the participant will be doing, can lead to an increase in interest and excitement (Alekh et al., 2018).

3.2.2 Fun in Doing

There are things that we adults would expect to influence the fun a child can have while learning. One of those things is usability. It is easily expected that if the platform you are using to learn (such as an IDE for programming) has an ease of use to it and efficient task performance, it would be more fun to use. This apparently is not the case, no significant statistical correlation between fun, usability and the learning effect has been found (Sim et al., 2006). Fun can come as an innate property of learning software. The ones with games are the most preferred when it comes to fun (Sim et al., 2006.) Scratch does excite learners to learn programming. It can be described as ”*a ton of fun*” (Malan & Leitner, 2007, p. 226), even. It also gives new programmers immediate rewards. The negative side of learning with Scratch is that other programming languages can seem too challenging and intimidating after it (Malan & Leitner, 2007.) Fun can also come from working with some materials. LEGO Mindstorms has been documented as being enjoyable (Stewart & Jordan, 2016). Even more than Scratch, LEGO Mindstorms have shown to be even more preferential (Merkouris et al., 2017). Some clubs hold play time specifically for the children to play and enjoy themselves. Sometimes the “work” they have to do in the clubs is preferable to the play time which ends up with children asking if they can skip play time (Weibert et al., 2016.) It is not fun to fail and Carroll (1988) mentions that success should always be within reach for the user. Challenges can be simulating and provide fun for individuals who want to test their spiel (Brandtzæg, Følstad & Heim, 2003).

3.2.3 Social Fun

Literature in the field of HCI does not look into social aspects of CS learning in a major way, therefore this part of this thesis is shorter. Shared joy is its double, sadness its half goes the old Finnish saying and that could be observed in the clubs and in interviews. Shneiderman (2004) says that for him, fun is social. This is not backed by HCI literature but is derivative of human nature and survival, therefore it can lead to different outcomes, for example in non-formal technology education. Participants from previous years’ courses have been observed to come to check up on the clubs’ for fun and might even light up the day there (Weibert et al., 2016.) Positive peer pressure can lead to heightened results when performing a task. Seeing others improve and succeed makes others more motivated to get there as well. Working together helps with tension and pressure attendees feel (Alekh et al., 2018.) Social interaction, effectiveness and satisfaction can also influence each other. Most likely by having a higher quality of collaboration between the members in the group, the processes they take upon themselves are more effective (Sharma et al., 2019). Social aspects can lead to other people being interested in these types of activities as well since children like to talk about how they are having fun (Alekh et al., 2018). Some researchers include group work de-facto into the fun category alongside with humor and games (Francis, 2013), which is reflective of the trichotomy of the different forms of fun in this thesis.

3.3 Ways of Measuring Fun

Fun can come from a lot of different things. It also can make itself apparent in multiple ways. Excited yelling and high fives can be considered such as other types of excitement (Stewart & Jordan, 2016). Laughter is the easiest way to tell who is having fun without asking them specifically, which is usually the best way but many times, it is important to know how a person’s experienced fun relates to others’. For that there are multiple different measures used in mainly quantitative and mixed methodology studies about how children perceive fun in products and the use of them. The “Fun toolkit” coined by Janet

Read uses the Funometer, Smileyometer, Fun Sorter and Again-Again table (Read, MacFarlane & Casey, 2002). For measuring fun in CCI (Child Computer Interaction), methods that seem more emotive are widely used (Read, 2012) and the emoticon-based Funometer and Smileyometer are a part of the Fun Toolkit. It provides researchers Likert type quantitative data on how participants perceive how fun the use of interfaces are with "relatable" smileys as scales (Read, 2012.) To scope out engagement, which is described as one dimension of fun as well, the Again-Again table asks the responder if they would like to perform a task again whereas the Fun Sorter asks children to rank items (Read, 2012). Some newer metrics have been introduced into the field of measuring experienced fun, like the FunQ by Tisza, Gollerizo & Markopoulos (2019b). FunQ relies on 6 dimensions: Autonomy, Challenge, Delight, Immersion, Loss of Social Barriers and Stress and gives the responder a Likert -style scale to respond to it (Tisza, Gollerizo & Markopoulos, 2019b). In quantitative and qualitative studies with questionnaires or surveys, it is good to keep in mind that children as young as 7 can discern between "high concept" ideas such as ease of use, fun and learning (Sim et al., 2006). Subjective (self-reported) fun, the reading of body language and listening for laughs, grunts and other explicit confirmation of fun are great ways to assure a researcher of its existence in a situation (Nielsen, 2003). Children typically just are in a "better mood" from adults' perspectives (Sim et al., 2006).

Children typically respond by giving higher or highest ratings if they are asked in what kind of mood they are in and things like Smileyometers might not give researchers the most reliable answers to questions they are asking (Sim et al., 2006). Children also respond more positively to tasks and products that seem interesting before surveying them (Read, 2012). Laughter can also be something people hide their insecurities and nervousness in. Fun does not really follow models, guidelines or principles of it: feelings of content, appeal and satisfaction are important factors when fun is measured (Shneiderman, 2004). While this study is qualitative and does not employ survey methods, it is important to acknowledge the different ways fun can be measured. The other point where these do not completely correspond with the subject at hand is that the literature focuses on fun in the way of a product and more specifically, something linked with usability and user experience.

3.4 Framework for Fun

As can be seen from the previous literature, fun is not the easiest thing to study and measure. Its definition is not the most straightforward either but it can be concluded that it comes from somewhere or something that makes you smile, less bored and/or even laugh. Shneiderman (2004) says that fun can come from many different things: physical things, like dancing, problem solving and even social gatherings. This reflects a lot on the observed and interviewed fun that was done for this thesis. Draper (1999) calls fun play for pleasure which leads to intrinsic motivation being satisfied by it and if intrinsic motivation is not the main reason of having fun, then some extrinsic ones can come into the picture. Challenges can be stimulating and provide fun for individuals who want to test their spiel (Brandtzæg et al., 2003). In the same vein, fun is a distraction (Blythe & Hassenzahl, 2003) and by employing that, it can be said that learning comes by itself. Fun as a distraction enforces the thought of it being a cognitive break, which allows the learner time to process what they have been taught (Garner, 2006). Motivation is important in having fun as well (Brandtzæg et al., 2003; Draper, 1999).

Fun presents itself in laughs, giggles, nudges in the shoulder and the like but it can also be completely intrinsic, a silent "yippee" in the back of the head, like it might be for most stereotypically stoic Finns. It was found during the observations that fun was had in three

distinct ways: pedagogically, by doing and socially. These are to be called “Pedagogical fun”, “Fun in Doing” and “Social fun”. These different categories were as well found in literature in such different ways that they can be described conclusively as somewhat different from each other.

Pedagogical fun is characterized as something “fun or humorous” that is done by the teacher in a classroom, usually a bit more formal one. Berk (1996) gives a list of humorous tactics that can be used in classrooms by the teacher and in conclusion, those tactics are jokes in materials and while teaching. Examples and intros are as well appreciated (Alekh et al., 2018). In practice these are observed when a teacher/instructor makes the attendees laugh or display other characteristics of enjoyment. It helps the observation as well if the researcher themselves is amused.

Fun in doing is characterized by performing a task and how the materials used to complete it relate to that. Success has been noticed to be linked in the interviews and observations as fun even though there is no prevalent literature about that. If success feels like a stretch in the “fun category” then imagine the feeling of winning something you have worked hard for. The feeling is positive, although a little less intense in an educational context but positive feelings are linked with fun (Sharma et al., 2019). This is why successfulness while performing a challenging task can be considered as fun in doing besides the obvious other mentions in this thesis as well as the ways of having fun while performing them and using fun materials.

Social fun is a bit broader than the other two classifications. It is characterized as a sharing of something amusing or entertaining with others. It is not as scientifically researched in the field of computer science education or engineering. Shneiderman (2004) mentioned social aspects as fun while listing different things that can be found fun. Some other types of fun, like the one from succeeding, can be expressed in a social way, for example high fiving (Stewart & Jordan, 2016), the social fun is characterized by sharing of something fun. In the observations, where this quality arose, participants talked with each other a lot during club time, shared designs and laughed together about the collective “fun stuff” they were doing.

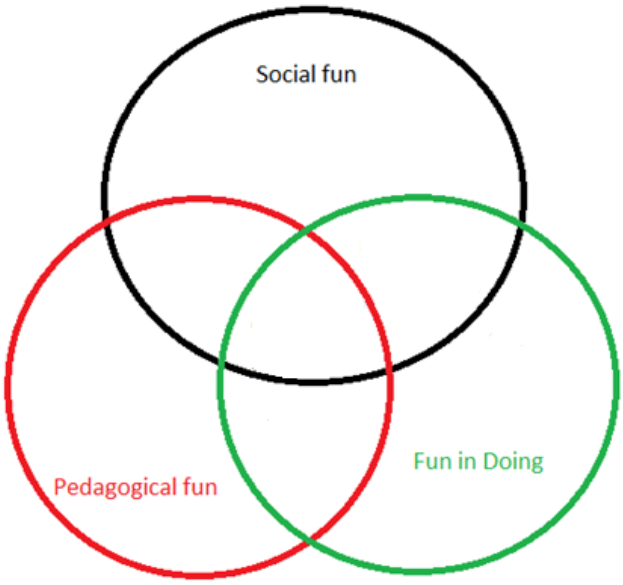


Figure 2. Different types of fun and their relationships to each other.

The cross sections in the Figure 2 diagram show how fun can be, for example, both socially and pedagogically fun. This framework is a result of a personal synthesis based on previous literature. For total clarity, the basis for this part of the literature stems from the need the field work presented, so in the end, the framework above used to analyze the data is influenced by the data itself so the results gotten from the process of analyzing are conclusive but to be taken with a grain of salt, so to speak. Table 5 below brings together the different types of fun with their context and gives some appropriate manifestation based on the previous literature read. This table is not definitive or scientifically concrete but does provide the reader a sense of the concept of fun as it is considered in this thesis.

Table 5. Types of fun with their contexts and possible manifestations

Type of fun	**Context**	**Manifestation**
Pedagogical Fun	Syllabi (overarching themes and lesson plans)	Enjoyment, Motivation to attend
Pedagogical and Fun in Doing	Material (such as Scratch's or Arduino's innate property)	Success, Humor, Excitement
Fun in Doing	Appropriate level of difficulty	Success, High fives, Enjoyment
	Overcoming difficulties or finishing projects	Success, High fives, Pleasure
Fun in Doing and Social Fun	Sharing and co-creation (of designs and ideas)	Success, Enjoyment, Humor
	Play	Laughter, Excitement, Pleasure, Enjoyment
Social Fun	Talk of popular culture, Socializing	Laughter, Other joyful expressions, High fives
Social and Pedagogical fun	Jokes from teacher (the role should be that of a teacher) or between peers	Humor, Laughter, Bringing teachers closer to students

The manifestations of fun are not standard for the different funs as is presented in Table 5 but they were the ones that were the most logical connections, therefore the last column of Table 5 should not be taken as fact but as an example of what is possible. The two first columns are based on the observations and the literature review above.

4. Methodology

This thesis is part of the "COM'n'PLAY SCIENCE" –project that is funded by the Horizon 2020 European Commission. Its mission statement says: "*The CoM'n'Play-Science project aims to help Europe better understand the new ways in which informal science learning is taking place through various coding, making, and play activities that young Europeans (children, adolescents and young adults) are nowadays increasingly engaged with outside school and higher education science classrooms, beyond the formal boundaries of science education.*" (COM'n'PLAY SCIENCE, 2017, p. 2) The project's aims are to investigate the different modes and locations where informal education takes place in. These include intentional and unintentional learning, where this thesis lays in the "intentional" learning category. The COM'n'PLAY SCIENCE -project has multiple partners from all around Europe and the work that has taken place in Finland at the University of Oulu is centered on empowering children with technology and empirical studies surrounding the non-formal education environment. This exploratory study into fun in non-formal education has three research questions based on literature, already done observations and the needs of the COM'n'PLAY SCIENCE -project: investigation of fun in intentional informal (in this thesis defined as non-formal) education.

In this thesis, qualitative methods have been used. They are mostly based on sociological literature as well as the Horizon 2020 project proposal of the COM'n'PLAY SCIENCE project and the COM'n'PLAY SCIENCE Deliverable 1.2 Research Instruments and Tools. The assessment of fun and enjoyment are done through observations and interviews (COM'n'PLAY SCIENCE, 2019). Qualitative methods are seen as a powerful tool of letting children communicate on their own terms (Barker & Weller, 2003) and they are the most typical way of finding out about what takes place in Maker Movement related activities (Papavlasopoulou et al., 2017). To have children at the center of research it is important to think about the method as doing science WITH children, not ON children (Darbyshire & MacDougall, 2005). Choosing between qualitative and quantitative research can be tough. Quantitative research can be seen as cold and impersonal and it usually has the "doing research ON children" connotation (Barker & Weller, 2003).

4.1 Observations and Ethnographical Approaches

Participant observation, fieldwork and ethnography are terms widely used interchangeably but there are some major differences between these practices. Ethnography can be considered the most inclusive term with fieldwork and participant observations as useful tools in it: fieldwork can be considered the data collection phase of the research outside of the research facility or University and participant observation besides the implied, usually includes interviewing the participants as well. It is not necessary for the researcher themselves to participate in the tasks the ones observed are doing but sometimes it is necessary for the researcher to understand what the fundamentals of the tasks are (Delamont, 2006.) Ethnography is a theorized account of the culture (or situation) studied with ethnographical methods. When employing ethnographical methods, before going to the field, the fundamental research questions should be formed to aim the conversations held, questions asked and the key observations to the right topic as ethnography relies on all the senses of a person. Three golden rules of ethnography are: meticulous recording of the process, failed access attempts are data as well and the harder the researcher has to work for access, the more rewarding it will probably be (Delamont, 2006.)

The key to data collection is to write and make notes as much as possible, the aim is to have a thick description of the surroundings. Recording is the most important thing a researcher does as it is the basis for analyzation (Delamont, 2006.) Photographs and video recordings are widely used as tools for documenting experiences for research practices. Pink (2006) proposes using photos as aides for evoking a reaction from an interviewee with photo elicitation. Asking participants to record their own stories might be a useful lens to view things from since it would show what the most important things to them were and what they think might interest the researcher (Pink, 2006.) It is important to hold duplicates of all accords as accidents can happen. Reflection should happen on all stages of research, even at the end of the observational period. Analysis is quite straightforward but some software might be of use, such as those used for transcribing (Delamont, 2006.)

To have a sound platform for the methodology, it is important to acknowledge the pitfalls of doing qualitative ethnographical research. Flyvberg tells in the book Qualitative Research Practices (2006) about the misunderstandings of doing case studies. They are as following:

1. *"General theoretical knowledge is more valuable than concrete practical knowledge.*
2. *One cannot generalize on the basis of individual case; therefore the case study cannot contribute to scientific development.*
3. *The case study is the most useful for generating hypotheses, that is, in the first stage of a total research process, while other methods are more suitable for hypotheses testing and theory-building.*
4. *The case study contains a bias towards verification, that is, a tendency to confirm the researcher's preconceived notions.*
5. *It is often difficult to summarize and develop general propositions and theories basis of specific case studies*." (Flyvberg, 2006, p. 421)

When there are time constraints and the resources of a research project are limited, it is useful to look into alternative ethnographical methods. One of those is short-tern ethnography (Pink & Morgan, 2013.)

4.2 Interviews

To conduct an interview, the researcher should know what they are going into and what they want out of it. Open ended questions are nice until you realize that the topic of discussion has gone way off base (Gibson, 2012.) Interview questions should not be answerable by just a response of yes/no/maybe. The "what was said" of interviews is not the only important thing: of interest is the way taken to get to the interview and how the interviewer and the interviewee ended up discussing the subject. This means that the whole context should be regarded as an important aspect of the interview, not just individual sentences uttered (Rapley, 2006.) Some kind of crafted interview schedule or "key" should be there to focus the interviewer on the topic at hand, since questions may change during the project or even the interview and evolve: sometimes prepared questions do not get asked. Question lists are multifunctional: they may work as something to take notes on in a bind and remind the researcher of the questions but they do not actually have to be followed closely (Rapley, 2006.) Some interview contexts can become hindrances, for example in public it is difficult for the interviewee to discuss their private matters and the interviewer should be able to ask their questions in peace.

Recording the interview session is advised but it is to be kept in mind that the recording device affects discussion but typically only when the device itself is mentioned. In some

sensitive cases, it could be beneficial for the interviewer to disclose their personal/biographical information to encourage an interviewee, but in general it is not necessary. The interviewer should drive to produce a relaxed and encouraging relationship and reflect on the questions asked but should not worry themselves about how "leading" a question might be (Rapley, 2006.) Interviews are considered conversational but not actually conversations, they are collaborative work and the interviewer should try to explore the mind of the interviewee in a nonintrusive manner by asking follow-ups to get the desired types of answers and allow the interviewee to talk at length (Rapley, 2006.) To engage children the most about what they are doing, it is smart to play "dumb" as in ask questions and to show their current project or task even if it was mundane and the researcher was very familiar with it (Darbyshire & MacDougall, 2005). Pre- and post-taping conversation should be acknowledged also in the recording of data. A study with only interviews as data are most likely a little limited and therefore should employ some observational aspects as well (Rapley, 2006.)

4.3 Ethical Issues

Ethical issues are experienced throughout the process of doing research but mainly when doing fieldwork (Ryen, 2006). Laws about storing and gathering research data do not exist in a way that would be easy to follow but for gathering and storing information for this thesis, the End User License Agreement (EULA) was employed in the consent forms to let the participants know that their rights are and will be respected. Informed consent is the cornerstone for gathering reliable information. There are difficulties in finding the line of informed consent and covert data collection, which is another data collection method, but generally in sociological research it is agreed that if any discomfort or negative experiences vanish by themselves or by a debriefing after data collection, research permit or consent is not that necessary (Ryen, 2006.) In this thesis it was not even considered to do covert data gathering since the study subjects were below 18 years old, but this proves another challenge: what if a person is harmed in a way that the researcher could not initially understand or does not realize? To build good relationships in the field, it is important for the researcher to produce and uphold trust between themselves and the study subjects. The road of trust works the other way too as researchers can be deceived by their subjects (Ryen, 2006.) To get the "truth from the horse's mouth" one needs to engage thoroughly with participants (Barker & Weller, 2003) which can seem forceful. High trust in the researcher might also be detrimental to the study as the subjects might get too familiar and start to restrict the researcher's movements and rights. Also the gender expression of the researcher may curtail the study as in women have less access to male dominated areas. Some things from interviewees can be considered "off the record" by their insistence if ethical dilemmas do come up (Ryen, 2006.)

Children are not capable of giving informed consent themselves (Kuula, 2011) which leads to an ethics dilemma: how to do research with children if it is not ethical to ask them for their consent. Kuula (2011) states that their guardian has given their written consent for their child to be studied with the right of the child to abdicate their consent. 15 years can be considered an age limit in Finland for a participant in a study to give their consent themselves but age does not equal maturity (Kuula, 2011.) In this thesis, every participant gave their consent, two adults (over 18-years-old) gave theirs orally, but others gave their consent on written forms.

4.4 What is Special about Research with Children?

Empowerment of children in research is a very valuable value to have, like stated before, it is important to do research WITH children instead ABOUT children (Darbyshire & MacDougall, 2005). Gibson (2012) talks about different tactics to be used when addressing children in an interview situation. In Table 6 she lists recommended strategies regarding trust, facilitating understanding and obtaining informed consent, encouraging thoughtful and detailed responses and promoting enjoyment and creative expression.

Table 6. Strategies for Interviews and Focus Groups (Gibson, 2012, p. 149)

Building Trust	Be familiar with and to the children before starting the interview.
	Have parents or other trusted adults present at the first meeting.
	Opt for a friendly and relaxed manner.
	Form a partnership with the children, not a hierarchical relationship.
Facilitating understanding and obtaining informed consent	Use child-friendly language to convey the purpose of the study.
	Inform children you are interested in their thoughts and feelings.
	Use ground rules to clarify the role that children will play in the interview process: • You can say ‘‘pass’’ if you don’t want to answer. • Take time to think before you answer. • Tell me if I don’t understand you, or if you don’t understand me. • There are no right or wrong answers; say what you want. • I won’t tell other people what you say. • Take turns talking. • No teasing or making fun.
	Invite questions and provide clarification.
	Obtain assent only after children fully understand the study and their role.
Encouraging thoughtful and detailed responses	Start with questions that can be answered with a brief, easy response.
	Primarily use open-ended questions.
	Encourage detail by using follow-up questions and prompts.
	Be patient, don’t be too quick to redirect or jump to conclusions.
	Refrain from providing cues or assistance answering a question.
	Use reflective statements, summary statements, acknowledgment of feelings, and praise for engagement generously.
	Sit squared off, in an open and relaxed manner; maintain eye contact; and match the child’s level of movement.
Promoting enjoyment and creative expression	Allow for movement or engage in familiar task like walking, drawing, or playing a nonverbal game
	Use drawing, journaling, role-play, and props.

To take Table 6 into consideration, the age of the one interviewed as well as their perceived maturity should influence the strategies. Gibson (2012) talks about children which is a demographic characterized by her as 8 to 12 year olds. The classical definition of teenagers is 13-19 (thirTEEN to nineTEEN) and during this study, the participants are not addressed as teens or children typically, only when literature calls for it, for example from developmental perspectives. Some age appropriate strategies were taken into account, for example, the researcher went into the interviews with children (8-12 years old) talking with a smile and a higher voice but with teens (13-19 years old) the interviews were more of a peer-to-peer situation where the interviewer let their natural dialect slip a little more. The interviews can be considered friendly with all participants, the researcher tried to make jokes and loose up the atmosphere with all study participants (both adults and underage) so that good insight would not be restricted by courtesies.

4.5 Methods Used

Non-formal learning has reared its head as a good way for parents and guardians to introduce a new hobby or other opportunity for kids to learn. Finland is many times considered a very advanced country in education and technology so it is quite easy to assume that non-formal education has taken roots here and that those types of educational instances would use the latest in pedagogical sciences. One thing to consider when it comes to foreign inventions and practices, everything comes to the north a bit tardily. (Some ice cream flavors get born, thrive and die elsewhere before Finnish retailers even have the chance to introduce them to the market.) Luckily, the last point is not how the picture is here when it comes to non-formal STEM education in the country. Even in the northern city of Oulu, three different companies could be reached that provide non-formal education in the field and got into a collaboration with two of the companies that provide a large range of different clubs and courses. Oulu is the fifth largest city in Finland so that might influence how lucrative companies see it as. The fact is that these types of opportunities can not be found in the large majority of geographical Finland.

The literature is quite clear on how qualitative research should be done. Field notes and interviews seem like the most typical way to do qualitative research in a situation like after-school clubs and the like. (Delamont, 2006) The lens of this study is on practices and fun (COM'n'PLAY SCIENCE, 2019) so the mentioned expressions of fun and enjoyment are the focus of observation. With children, it is important to be familiar to them before interviews to get the most candid answers and for the participant to have as much of an enjoyable time as possible. For the interviews of the adults, the tone used can be more direct and to the point than with children (Gibson, 2012.) The long form of questions for the study can be found in the Appendix section.

4.5.1 Data Gathering

Data was mainly collected by notes and interviews. Videos give a nice look into fun but it is more reliable to have statements of self-reported fun. There is around 8 000 words of notes in Finnish (an agglutinative language so in English it would be more) about the observations, focus on the "fun" parts. From the 55 people consenting to the study, there were 22 interviews, six with instructors ranging from 17 minutes to around 50: in total this is 210 minutes of interviews. With attendees and their parents or guardians it is harder to calculate as a few interviews were held together with child and parent. In total there is around 208 minutes of interviews. Six parents of attendees were interviewed (one from Koodikärpät-kerho, the others from Tiedekoulu. It was easier to reach parents from Tiedekoulu as they sometimes came to see what their child had done during the day and came to pick the children up). Ten children were interviewed. The data reaches around 7

hours of recordings. There is less than an hour of video footage in total but it gives a nice context to the fun. Video recording was not the most ethical way of producing data as everybody in the clubs did not consent to the research and it was hard to respect the privacy of people not consenting since people moved around a lot.

After observations, the times for interviews were set with participants who were interested. Some movie tickets could be provided to those who wanted to be interviewed, which led to 22 interviewees. The interviews were not too long for the participants and their parents, approximately 10-15 minutes each. In total there is about 7 hours of interview material for this master's thesis. This is why selective transcription is done for the interviews. The interviews were recorded doubly with a recorder and a smart phone, thusly having already backups, the analyzed files did come from the recorder in .wav format which then were opened and transcribed into a .docx file. Every interview was filed with the same name as the one(s) interviewed thus keeping the records straight, the same method was used for the names of the transcriptions. As was stated, the interviews were mostly done in Finnish, two were held in English since the two attendees spoke English together and were from the international school in Oulu. Those two interviews were transcribed in English as well. Due to the nature of the clubs, no visual aids could be used during interviews. In Tiedekoulu's robotics clubs the LEGO Mindstorms robots were disassembled after every club and from the programming club only one participant was interviewed. He showed his work on the computer thus the thesis writer got some idea how the projects the participants do relate to fun in a more concrete way. At Buutti's Koodikärpät-kerho's programming club the participants interviewed used the computers at the university and due to the nature of the study and not wanting to disrupt the status-quo of the clubs, the visual aids were not used. At their robotics club, most interviewed did not bring their old designs with them while they were working on their own. The ones interviewed were not asked to bring their old designs with to not disturb the clubs.

The observations took place during two months, the two clubs were held mostly at the same time in totally different parts of Oulu so the observations had to be planned a bit more clearly. The notes of the first five (3 for Tiedekoulu, 2 for Koodikärpät-kerho) were more extensive, for the next sessions a camera to film things the attendees wanted to get filmed was implemented and notes on "special" occasions, like things that were said that were out of the ordinary and how fun was had. For the first 2 weeks (a total of 12 meetings) the Tiedekoulu was observed. The same attendees usually attended the one club per week. The next three weeks were mostly observations at Koodikärpät-kerho, once at Tiedekoulu but there the message from some children was that "are you here again?!" so the researcher wanted to give them a little space for the next two sessions. This was something that was predicted by Ryen (2006). After the observations in both instances, the times for interviews were set with participants who were interested. The interviews were not too long for the participants and their parents, approximately 10-15 minutes each. Table 7 has the condensed story of the observation and interview times and amounts. The questions were heavily based on the COM'n'PLAY SCIENCE deliverable 1.2. "Research Instruments and Tools" (COM'n'PLAY SCIENCE, 2019) and their rough versions in English are added as Appendix in the end of this thesis. The questions were translated to Finnish for the participants and instructors but since there was an opportunity to interview parents, a list of questions based on the one for attendees was formulated but from the perspective of the parents. The formulation happened based on the questions asked of the attendees and adding the perspective of the parent or guardian on top of them, so instead of asking "Is the club fun?" the question for the parents/guardians was "Have you been told that the club is fun or have you noticed that your child enjoys the club?".

Table 7. Club dates and times alongside with observation and interview dates

Club	Time and duration	Observation dates and times visited	Interviews (which's dates can be verified)	Videos and photos
Koodikärpät-kerho's Robotics	Tuesdays 16-19 Thursdays 16-19	19.3.- 25.4., 6 times observed, 18 hours.	18.4., 23.4., 7.5., 15.5. 4 interviews	16 videos (4 secs – 2 minutes), 41 photos
Koodikärpät-kerho's Game Development	Tuesdays 16-19	26.3.-23.4., 5 times observed, 15 hours.	23.4. (2 interviews), 10.5. 3 interviews	1 video (16 secs), 8 photos
Koodikärpät-kerho's Web Development	Tuesdays 16-19	26.3.-23.4., 5 times observed, 15 hours.	16.4. 1 interview	0 videos, 3 photos (of the space, no attendees)
Koodikärpät-kerho's Android Development	Tuesdays 16-19	26.3.-23.4. ., 5 times observed, 15 hours.	17.5. 1 interview	0 videos, 5 photos
Tiedekoulu's Programming	Tuesdays 18-19 Wednesdays 19-20	12.3.-8.5., 10 times observed, 10 hours.	8.5. (2 interviews), 9.5., 23.5. In total: 4 interviews	12 videos (11 secs – 13 min), 3 photos
Tiedekoulu's Robotics	Tuesdays 17 -18, 19 -20 Wednesdays 18-19 Thursdays 19-20	12.3.-8.5. 13 times observed in total, 13 hours.	23.4, 29.4., 7.5., 8.5. (3 interviews), 9.5., 23.5. In total: 8 interviews	49 videos (2 secs – 7 mins), 9 photos

In Table 7, the two tiedekoulu's teachers were counted twice since they clearly contributed to both clubs, therefore the column "Interviews" does not equate to the actual number of interviews. The methodology used for this study heavily relied on sociological literature as well as the COM'n'PLAY SCIENCE Delivarable 1.2. "Research Tools and Instruments". Most of the methods and their ethics are gone through in a previous chapter. Videos give a nice look into how fun was had but it is more reliable to have statements of self-reported fun. There is around 8 000 words of notes in Finnish (an agglutinative language so in English it would be more) about the observations, focus on the "fun" parts. From the 55 people consenting to the study, there were 22 interviews, six with instructors ranging from 17 minutes to around 50: in total this is 210 minutes of interviews. With attendees and their parents or guardians it is harder to calculate since a few interviews were held together with child and parent. In total there is around 208 minutes of interviews. Six parents of attendees were interviews (one from Koodikärpät-kerho, the others from Tiedekoulu. It was easier to reach parents from Tiedekoulu since they sometimes came to see what their child had done during the day and came to pick the children up). Ten children were interviewed. The data reaches around 7 hours of recordings, there's less than an hour of video footage in total but it gives a nice context to the fun. Video recording was not the most ethical way of producing data since

everybody in the clubs did not consent to the study and it was hard to respect their privacy since people moved around a lot.

The analysis of the data was purely qualitative and therefore subjective. Notes were primarily written in the first club sessions observed with pen and paper and the focus of observation was on how the clubs work and if the participants are having fun, how does that show. The interviews were transcribed and notes made on when there was laughter and whether it was nervous or genuine but ultimately it was up to the researchers to decide based on the previous literature. With all the material, the focus was mostly on fun, since it is harder to discern than the structures and characterizations of non-formal education in Oulu.

4.5.2 Data Analysis

For analysis, the notes were referenced mostly for practicalities and expressions of fun. The notes were made on paper, so they were typed out on a computer and saved as .docx files for safekeeping and further recollection. Since the amount of interview data was surprisingly massive and every interview held a small nugget of important information about the characterizations of non-formal education and the nature of fun in them, the transcriptions were mainly done about the most important parts for this thesis. Since the interviews were mainly structured and based on the questions in the Appendix, the choosing of which parts to transcribe was quite straightforward. The questions that answered to the practices of the clubs were mostly along the lines of "what do you do in the club?" and "how typically does the club proceed" and were answered in interviews as well as the ones including fun ("is the club fun?" and "what is the most fun?").

From observations of five whole sessions, fun was found in sharing experiences and designs, playing with and enjoying the things they produced and just by attending the clubs doing what was in-program via the footnotes taken. There was one group where no potential interviewees arose, they did not give consent either, so not all of the findings apply to the web-development club at Koodikärpät-kerho. Memes were also relevant in all of the other ones, they were reactions to others work, fun things to throw out in certain situations and even existent on some works the participants made. The above mentioned factors were further confirmed in the interviews that took place in the last few meetings. From interviews it was also apparent that the worst thing about the Koodikärpät-kerho's club is that "it is so short". Attendees genuinely appreciated the club, some attendees told that they attended all multiple times after they had passed the "four times for a chance of a summer job" –quota and expressed like they genuinely enjoyed the club and its freedom. Fun in doing was the easiest to record in photos. Snippets of code might not have been the most "fun" to look at but since most coding activities observed were of something with "real life consequences" like a game or a metal detector, the fun was visibly apparent. The Table 7 below shows how the timing of the data gathering and times for the clubs. All of the clubs' final meetings were observed, but the clubs had started before the observations began.

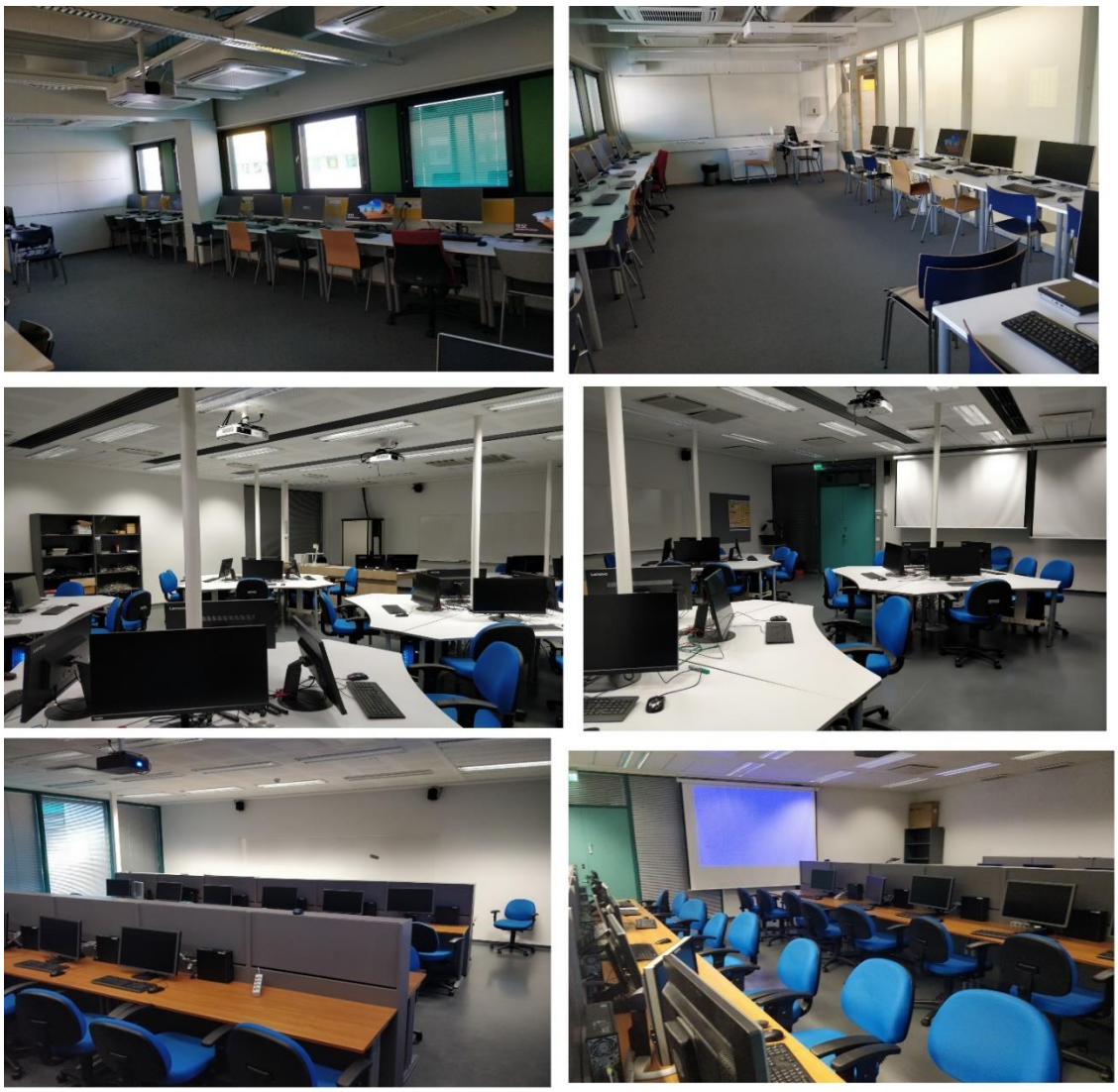
5. The Instances of Non-formal Technology Learning in Oulu

The results of this thesis are written in the same format as the Ventä-Olkkonen, Lanamäki, Iivari and Kuutti (2018) study's about practices engaged around an interactive public display. They report their findings as "*4.1 Historical and spatial context of practices. 4.2 Zooming in on the display practices as performances 4.3 The display practice from the perspective of space, tools materials and the body 4.4 Social perspective and meanings associated with display practices 4.5 Summary"* (Ventä-Olkkonen et al., 2018). Even though the topic differs heavily between Ventä-Olkkonen et al.'s paper and this thesis, there are similar patterns for the paper to be helpful in digesting the results of this thesis. The topics in this thesis revolve around the practices, characteristics and fun in the clubs and therefore this part of the thesis is divided into a few areas responding to the research questions' topics as well as having the background of the clubs as a separate thing. The 4.1 in Ventä-Olkkonen et al.'s paper responds well enough with 5.1 and 5.2 in this thesis as they all describe the context. The next comparison is between their 4.2 and my 5.3 as they both describe practices. The inclusion of this source here is so that this thesis can pay homage to writers whose paper helped the writer to sectionalize the thoughts in their head.

5.1 Koodikärpät-Kerho

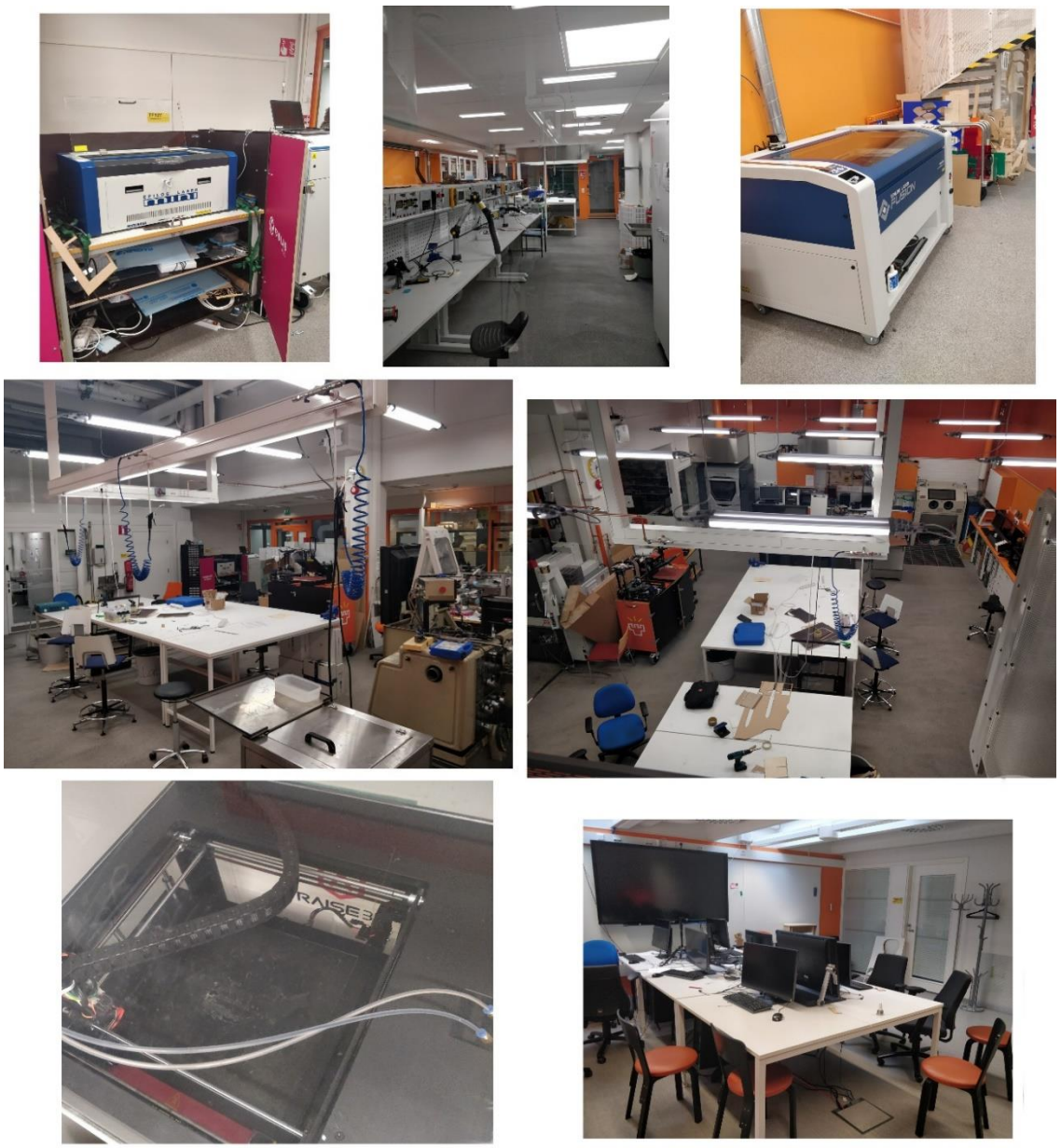
Koodikärpät-kerho is a club held by Buutti Education primarily for 15 to 17 year-old Oulu area residents who are looking for a summer job in the field of IT and engineering during the spring as of these observations. Other people outside of that age range may participate in their program in a hobby sense. The club is free and the materials are mostly provided by Buutti. During the spring of 2019 they held the Koodikärpät-kerho for the first time and they had two main divisions: robotics and programming. In their programming club, they had game, web and Android development as their separate subjects. Robotics was mainly 3D printing, laser cutting and Arduino centric Maker Culture related activities. Group sizes varied day to day, club to club but in general, there were around 20-30 participants in the game development group, 10-15 in web, 10-15 in Android and 20-30 in robotics. The programming clubs were held every Tuesday from 4 p.m. to 7 p.m. for 5 weeks and the robotics club every Tuesday and Thursday for the same period of time as the programming clubs.

Koodikärpät-kerho operated the spring of 2019 totally within the University of Oulu, Buutti does have a "mobile FabLab" that they have taken around different educational contexts. Buutti Education has held a Koodikärpät event before but the club that was studied was held for the first time during the spring of 2019. As of August 2019, they have informed that the next Koodikärpät-kerho will be held multiple times a week and they will have enrolment and caps on the amount of attendees (https://www.koodikarpat.com/kerho/, read 29.8.2019). Buutti does a lot of cooperation with the University of Oulu and the Chief Education Officer gave us permission to study the different Koodikärpät-kerho activities they provide. The different spaces that the clubs took place in are depicted in Picture 1 and Picture 2 below.



Picture 1. Pictures of the computer rooms at the University of Oulu where the Koodikärpät-kerho's programming clubs took place in.

The programming clubs' spaces, although different, functioned in a similar manner. In Picture 1 above, the 3 different spaces at the University of Oulu, where the programming clubs took place in, are depicted. The spaces were geared towards education, so they suit the clubs quite well. Teacher is sitting down behind a desk or close to the monitor while the attendees worked. There was a lot of movement still because the teachers helped the attendees and other participants wanted to show their friends what they have found online or what they have made. During the interviews, some attendees were extremely candid about what they did in the clubs. There were two attendees at the Koodikärpät-kerho's game programming club who were interested in getting some movie tickets. These two took part in the game development club weekly and told that they usually work according to a vague plan: first they spent an hour on the game, take a 5 minute walk, play around online for an hour and then work one more hour during the three hour club. The attendees are free to come and go as they please, especially these two since they are not applicable for the summer job voucher because they are under 15 years old. These two and one other participant were the only ones interviewed from Koodikärpät-kerho's programming clubs so their input has been very valuable.



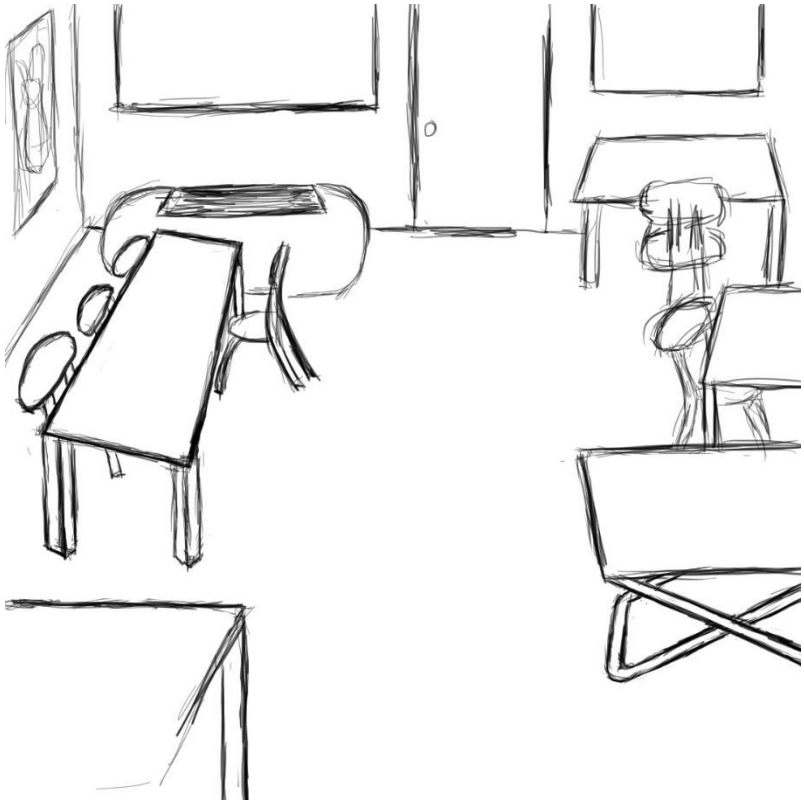
Picture 2. Pictures of the University of Oulu's FabLab where Koodikärpät-kerho's robotics club took place in.

The FabLab at the University of Oulu (in Picture 2 above) is a multi-level space with lots of equipment. Upstairs were the computers that the attendees (and other people as well) used for modelling etc., downstairs is the "protopaja", which is technically an electronics workshop. There people mostly worked with Arduinos and LED lightstrips. Then there is the FabLab in itself, it is a large space with multiple laser cutters and 3D printers. The RAZOR3D was in the FabLab during the club but nowadays it is in another space. The photos were taken after the club has ended to respect the privacy of those who did not consent to their likeness or projects being documented. In the FabLab, besides the main Making related activities, all the supporting actions, like filing, cutting and sandpapering took place. The instructors and attendees usually moved around very much. The robotics club's usual procedure for the attendees is quite simple: pick up where you left of (there is a storage space on the grounds) or start designing or ideating a new project, continue work, ask if there are problems, clean your space, store your stuff and leave.

5.2 Tiedekoulu

Tiedekoulu provides younger children (now up to age 15) non-formal, structured education around Finland in around 20 cities and towns. They provide a plethora of courses in robotics, programming, animation and science. The Tiedekoulu clubs are geared towards 4 to 15 year-olds and they gave permission for their more advanced clubs which typically held the older participants to be observed. Those took place at the same space (in a day care center depicted in Picture 3 below) and around the same time. Tuesdays were two different robotics clubs and a programming club, each one hour during evening from 5 to 8, Wednesdays one robotics and one programming from 6 to 8 and Tuesdays one robotics club from 7 to 8.

Tiedekoulu's clubs took place in a day care center that Suomen Tiedekoulu had a cooperation contract with. They hold Tiedekoulu's clubs all around Finland, many of them in Oulu but since our interest was in attendees who already went to formal school, the founder and CEO of Suomen Tiedekoulu offered for their more advanced clubs to be observed and studied. The building materials were usually on the one table closest to the perspective of the researcher, the long table was the most frequently used by the attendees. The closest, diagonal table is where the teacher sat when they organized stuff. The walls of the space were decorated by the usual people who used the daycare center daily and so created a familiar, soft and almost fun environment. Sometimes the different elements there on the walls and the ceiling brought joy to the participants. The space is depicted below.



Picture 3. Picture of the space Tiedekoulu's observed clubs took place in.

The space is designed for younger kids to spend hours upon hours in daily so the space had different little fascinators everywhere, like a map of Finland, holiday plans and

seasonal decorations. Sometimes the space itself became a distraction since it was such an amusing room with decorations that seemed interactive even if they actually were not.

5.3 Practices

The Koodikärpät-kerho functions on a free to come, free to go basis. The instructors kept track of who was present during the meetups mainly because the participants who had the city of Oulu issued summer job coupon could apply for a summer job at Buutti after attending at least four times. At Tiedekoulu, the attendance was tracked but there were no repercussions for missing a session. Usually the children who missed the previous time were asked if they wanted to check out the previous topic in robotics club, at their programming club, most of the time was used on a game project in Scratch. Typically, in both of the programming clubs (Tiedekoulu and Koodikärpät-kerho) and Koodikärpät-kerho's robotics club the attendees continue from where they left last time. In Tiedekoulu the continuing of one's work was pretty straightforward since the attendees had their own computers; some projects were "lost" as in the name could not be immediately remembered. After the first time in Koodikärpät-kerho there were apparently some difficulties since the computers at the university reset occasionally, so the files saved do not stay there for long. The attendees were instructed to send the files to themselves via email or save them on a USB-drive. In the robotics club, all projects were gathered in a room for the next time if they were still unfinished.

In Koodikärpät-kerho, the instructions and help to start your project were projected on a screen or displayed on a TV for attendees to notice them. The projected pictures usually included signing-in help and URL addresses to Google Drive folders where more in-depth instructions could be found. The instructions were divided between games, programming and robots by having different web addresses for all. The group focusing on web development used freecodecamp.org as their primary educational source and although it is not in Finnish, most attendees managed well with only English; some minor linguistic problems did arise but were easily solvable. All the attendees in Tiedekoulu spoke Finnish and generally were younger so it was implored to have everything in Finnish. There were only small problems when the micro:bit IDE switched language to English but the problem was quickly tackled. Materials for the robotics club with micro:bit and programming courses were online in their own website with a curriculum to follow and the LEGO Mindstorms robotics clubs had laminated paper instructions distributed to the children. There was a large, heavy folder where the week's instruction laminates were given from.

5.3.1 Social Aspects of Attendance

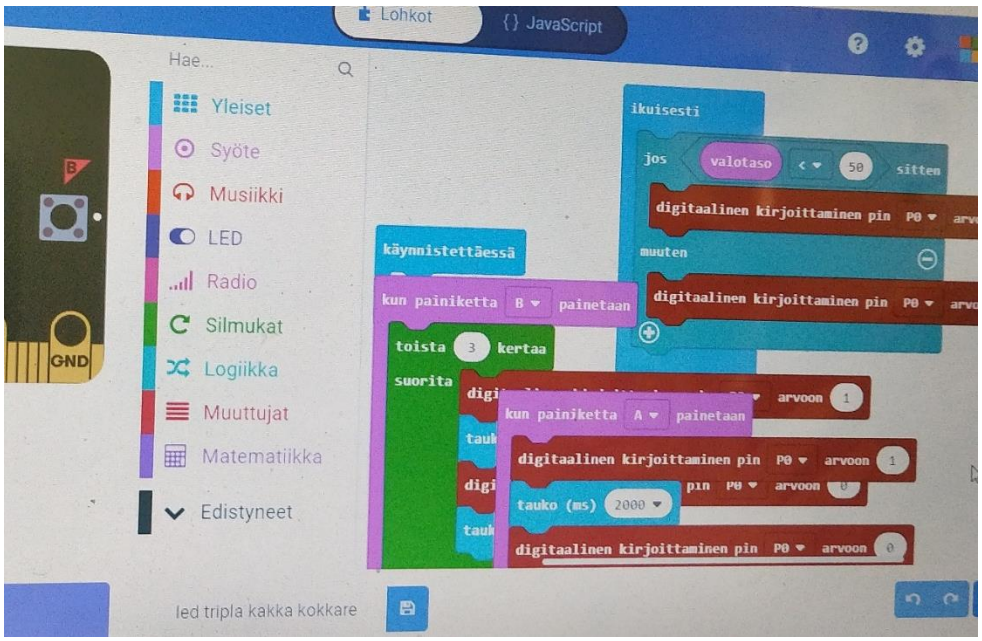
Work was done mostly individually in both instances, collaborative efforts were nonetheless frequent; taking inspiration from others' designs, coding a game together and solving problems together at Koodikärpät-kerho, building robots together, sharing fun design ideas for games with other participants and playing/gaming with each other during club time in Tiedekoulu's clubs. The interviewed attendees always felt like they got enough help from the instructors and did not express any problems with them. There are two possibilities for this result, either the ones interviewed made the most noise as they were the ones actively asking for the movie tickets as well or the instructors actually managed to be as good as they seem. There were sometimes during the observations when a calmer, quieter attendee did not get the attention they needed immediately when asked, the instructor instead went to aid another attendee who made more of a ruckus. One of the interviewed instructors confirmed this to be something of a bias but still, the quieter

ones always ended up getting the help they needed and maybe the “class dynamic” works better when there are people attending who are willing to be a bit more flexible.

Cooperation was important as well between the attendees. Some made whole projects together like the ones interviewed and observed at the game development club at Koodikärpät-kerho, sharing ideas and designs, like in the robotics club at Koodikärpät-kerho, collaborating on robot builds, designing sprites together in Tiedekoulu’s programming club or building robots to compete with each other in the robotics club at Tiedekoulu.

5.3.2 Club Procedures

The procedure at Tiedekoulu’s clubs was managed by the teachers and the programming and coding clubs had different things for the children to do. The teachers usually arrived a little earlier than the attendees to go over the topic of the lessons. For programming clubs the procedure normally was 1) greetings, washing hands and waiting for other attendees 2) opening computers 3) teacher telling the children what the topic of the day is 4) programming 5) finishing 6) shutting down computers and leaving. Some play took part in almost every step in different forms: playing with their phones while waiting, playing other games on Scratch, plying with the Scratch Sprite creator, playing with friends and showcasing their designs. In robotics clubs there were two main technologies in use: LEGO Mindstorms and BBC micro:bit. With LEGO Mindstorms, they 1) greeted, washed their hands and waited for other attendees 2) got told of the topic of the day by the teacher 3) started gathering resources 4) building the project, mainly from an image or instructions 5) if managed to finish, playing and improving the design 6) taking apart the built structure and putting the blocks into the right containers 7) leaving. For the Lego Mindstorms activities, fun can be seen with playing with their creations. Especially the cars (like in Picture 5 on page 44) they built on a few occasions seemed to be supremely fun. Building and making “unorthodox” designs seemed to be exhilarating as well. Hammers turned into “torture chairs” etc. For micro:bit: 1) greetings and waiting for other attendees 2) opening computers 3) teacher telling the children what the topic of the day is and distributing the micro:bits 4) programming the micro:bit with their own laptops 5) checking the functionalities and playing with the micro:bit 6) returning the micro:bits and closing the computer 7) leaving. The specific fun with the micro:bit came from the different properties of it, like the metal detector or thermometer. It was always (perceived) as enjoyable when the kids could try out the different properties they are utilizing in the code for the micro:bit.



Picture 4. Code for micro:bit from an attendee.

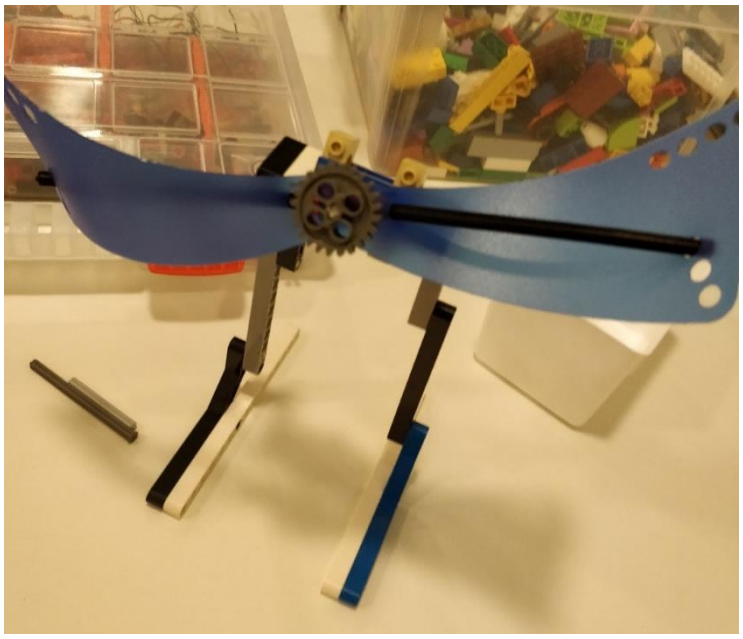
The Koodikärpät-kerho functions with a bit more of an open doors policy. People can pop in and leave at times most convenient to them. Usually at some point during the session, names of the attendees are gathered mostly because Buutti Education provides 15- to 17-year-olds a possibility to work with them during the summer as a part of the Oulu city's summer job coupon program. At all times, there are some information about how to continue or get started projected on to the screens in the spaces, but the instructors are there to help with whatever problem the attendees have from opening the correct software to programming aide. The programming clubs were usually more silent. If there were laughs, they were from the rows in the end and about stuff that was "off topic", like sharing YouTube videos with friends. Enjoyment in those situations was a bit more difficult to find but from interviews, it was clear that attendees found it from the work they were doing, both the process of programming and succeeding in a difficult task. The robotics clubs were a bit louder and more talkative but still calmer than the ones held in Tiedekoulu, most likely due to the age and maturity of the attendees. There the procedure lived in the moment. New attendees were acquainted with the space and the instructors and the old ones would continue working on a project they had stored in a room upstairs of the Fab Lab space.

5.3.3 Used Technologies and Materials

Previously in chapter two of this thesis (2.3 and its subparagraphs), technologies used in these clubs were introduced. For Tiedekoulu's robotics clubs LEGO Mindstorms robots with EV3 control units were used to introduce the children to mechanics and basic robotics and the micro:bits for a little bit more advanced group. They both seemed to fit the needs and level of knowledge of the attendees quite well. From the interviews it became apparent that most if not all attendees had taken part in previous clubs of the same topic, leveling the playing field so to speak.

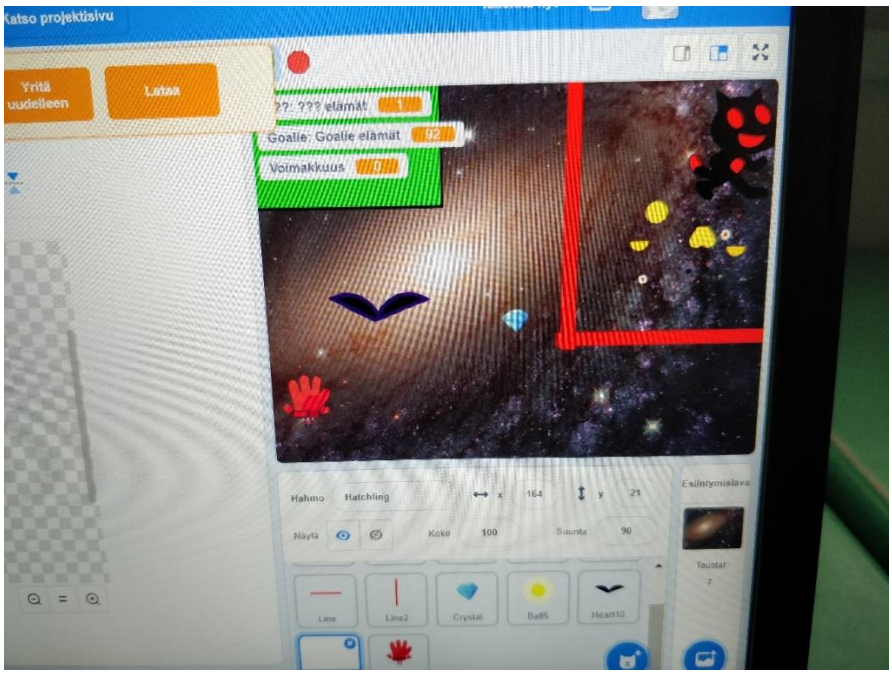
Picture 5. LEGO Mindstorms car made by an attendee.

The cars were one of the last things that were made during the club as they are a little bit more advanced than for example the windmill (Picture 6 below, made by the researcher). These more rudimentary objects were to teach the attendees about basic mechanics and structures. one of the development ideas of a teacher was that the continuation of the topics could be improved, as in using previous week's subjects as a starting point for this week's or by having larger projects to build over time. The problem there is, as stated by the interviewee, was that the designs had to be taken apart after every class.



Picture 6. Windmill of LEGOs built by the researcher based on Tiedekoulu's instructional leaflets

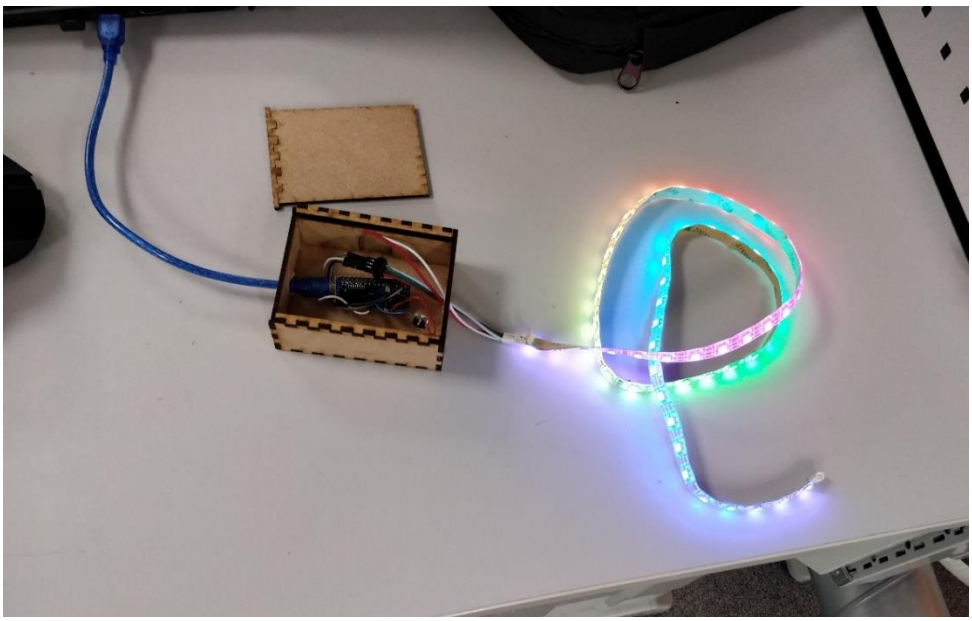
For the programming clubs, Scratch (Picture 7 below) was the most used technology in the Tiedekoulu's clubs. This may be a little skewed since the clubs observed were the most advanced ones. At the end of the programming clubs' curriculum was a Python part that was done with an in-house developed integrated development environment for educational purposes to introduce the element of angles and directions in code outside of the block-language base.



Picture 7. Sprites in a Scratch game designed by a Tiedekerho's programming club attendee.

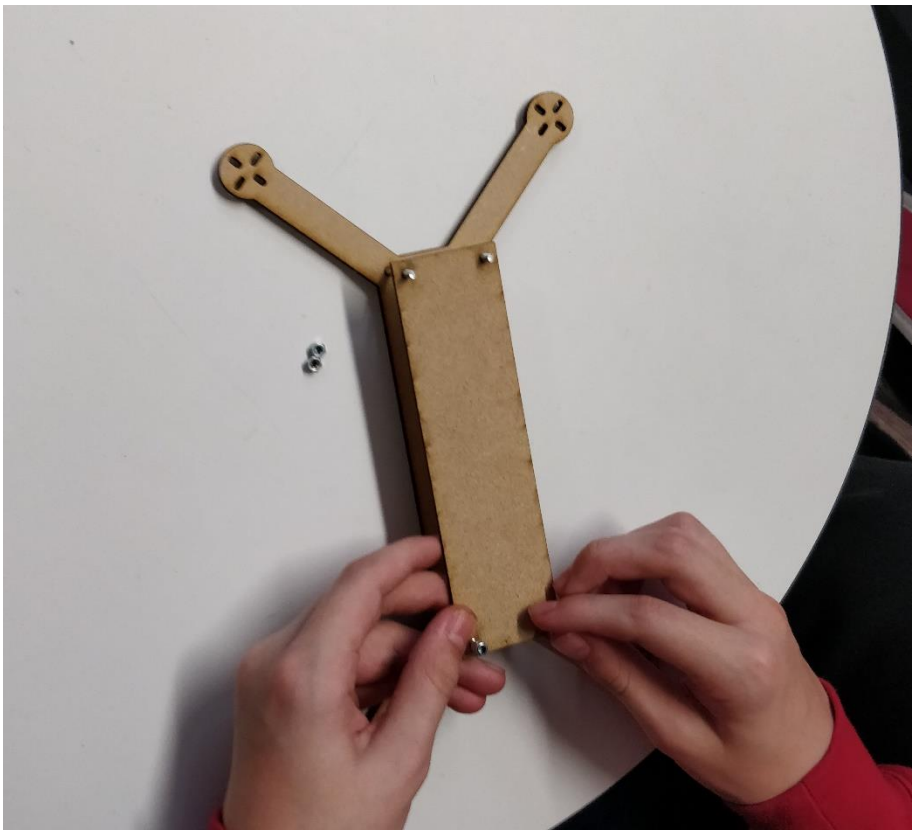
The attendees of Tiedekerho's programming club virtually all made the same game but with different visual effects. The one above is one of the more creative ones since the cat is almost completely blacked out instead of its eyes, mouth, end of its tail and paws. There was limited freedom in the expression of the functionalities but the outward appearance of the game could be what ever the attendees imagined.

The next two pictures are of Koodikärpät-kerho's attendees projects. There were multiple technologies included in them, Arduino being the most prominent. Even though the robotics club sounds to be more linked to learning mechanics, there was a lot of programming, like with Tiedekoulu's micro:bits. The Arduinos were used to control other technologies, most usually LED light strips that were provided by Buutti Education. Besides the technologies the attendees personally worked on were the laser cutters and 3D printer, which were so popular that most attendees waited in line to use them. The RAZED 3D was described by the Koodikärpät-kerho's instructors as extremely fast and it veritably was. It was almost always printing during the club but the lines worked to a level that no complaints about someone cutting the line could be heard and usually even if the project printed was on the larger side, it was cut to sections either due to mechanical issues or for courtesy towards other attendees. In picture 8 there can be seen two of the three most used techniques; laser cutting and LED strip programming via Arduino Nano. Picture 9 is of a casing for a drone. The attendee making the drone attended a club that was held on Tuesdays mostly, so their progress could not be mapped totally throughout the making process, but the drones were a popular enough topic in general. The researcher got to fly a drone during one club as well.



Picture 8. LED strip controlled by an Arduino within a laser cut case made by a Koodikärpät-kerho attendee.

In the Koodikärpät-kerho most of the consent forms came from the robotics club. The photo above is of a LED strip to be used as a computer screen lining for a cool visual effect. The LED lamps and lights are the most prevalent type of project in the robotics club and it employed multiple different things that could be done in the club: programming Arduino, electrical work and laser cutting or 3D printing to make a case as in picture 8 or for example a wall mounted fish like one interviewed participant had done.



Picture 9. Drone casing made by laser cutting by an attendee of Koodikärpät-kerho's robotics club.

Drones were a hot topic as well, one of the instructors at the Koodikärpät-kerho brought a demo for flying his self-made drone and attendees got to try it with the controller on a computer.

5.3.4 Participants

The initial age range of the participants was 12-19 based on the needs of the COM'n'PLAY SCIENCE –project but due to Tiedekoulu having mostly younger students, the range was used as a suggestion rather than a guideline given in COM'n'PLAY SCIENCE Deliverable 1.2. In the end, the age range informed by the consent forms given back solidified at 8-17, which is well represented in the interviews as well. Finnish was spoken with the majority of attendees, there were two in Koodikärpät-kerho's gaming club that spoke English with the researcher and their interviews were in English as well. Altogether, 33 participants from the two clubs returned the consent forms, 8 participants gave their consent through Google Forms, most of the teachers consented to the study as well and there were 16 of them, 6 interviewed. 6 parents were also interviewed, all gave their consent. At Suomen Tiedekoulu there were around 4 to 7 participants in every gathering, ten at most. It lays better into the non-formal education distinction than informal since attendance was not mandatory but they moved further into a subject every time. Children that gave the consent form back were 8-12 year olds, all assumed boys: the research question did not focus on gender issues so gender of the participant was not asked. The clubs there were held in Finnish. With the Koodikärpät-kerho, it is hard to approximate the number of all attendees but in general, programming club had 10-60 attendees (depending on subject) at a time, robotics held around 20-40 attendees at a time. The age range was a little bit more unclear but from the consent forms returned, the ages were 11-17. Attendees were mostly assumed male, there were a few female assumed participants and research permits were given by two, no interviews though. The material was in Finnish but English was used to a degree as well. Most children had done something related to their clubs as a hobby or were just interested in the field in other ways. Some attendees have not even had IT or CS education in formal school yet.

Table 8. Participant and interview information

Club associated with	Role	Age range (if asked)	Consents given	Interviewed	Approximate length of interview
Koodikärpät-kerho	Instructor	-	13	3	32 minutes
	Participant	11-17	15	6	11 minutes
	Guardian	-	1	1	21 minutes
Tiedekoulu	Teacher	-	3	3	38 minutes
	Participant	8-12	18	4	18 minutes
	Guardian	-	5	5	11 minutes

At Tiedekoulu, parents were asked not to come to the space after or before clubs but almost every club had some participants' parent(s) or guardian(s) visiting the space to see what their child has done or to help them set up their computer. One time, there was another teacher-to-be at the club to see how the club works and to have some ideas when

they would hold a similar club next semester. At Koodikärpät-kerho, in the programming clubs it usually was just the participants, teacher(s) and the researcher but in the robotics club, other university staff and students were present. The amount of people was in flux most of the time, so the only viable approximation is that there were 5-20 other people present at the FabLab, in the programming clubs, there sometimes was a university student in some corner if there were enough spaces for everybody. Parents and guardians were also asked if they would like to participate in the study. A good number of interviews from the parents of the attendees of Tiedekoulu's clubs were given and one from the Koodikärpät-kerho. They were asked to consent by paper or orally. 3 parents were assumed female and the other 3 assumed male.

Instructors had different educational and employment backgrounds, there were two with experience in pedagogy, many with IT; most Koodikärpät-kerho's instructors were employees of Buutti who have other responsibilities within the company, such as programmer, and their primary roles in the company was not necessarily that of an educator. One instructor that was interviewed told a long list of different teaching credentials related to sports etc. He also told that the club felt like a good past time for him personally and a good place to learn new things. Both of the interviewed Tiedekoulu's teachers had experience in teaching but in different ways, one has studied to become a teacher and the other has worked as a substitute teacher previously. They both stated that they did not have experience in programming but tried to keep a few steps ahead of the attendees in the clubs.

Motivations for attendance were mostly intrinsic, which is to say that the motivation came from within the participant, not from another place. One interviewed parent told that they specifically tried to make sure that their involvement in the IT field did not influence the child's interest in this field and therefore their hobbies. The attendee himself reported that he loved videogames and would like to be a game developer in the future, which is enough of an intrinsic motivation. Videogames seemed to be the hot topic for attendees, a lot stated that games were of interest when the interviewer asked for their motivations. One Koodikärpät-kerho attendee who was interviewed stated "jealousy" as his motivation, as in that he could not attend one of the mobile fab lab sessions some Buutti Education employees with University Fab Lab do around the schools of Oulu and came to check the club because he missed the mobile Fab Lab one. The motivations of the participants for attending the clubs are varied. Usually the attendees stated themselves that they came to the clubs because they "wanted to become videogame programmer" or "because it seemed interesting and we do not have anything like this at school" for example. From the interviews with the parents of the participants arose another idea: most of the adults interviewed work in a similar or adjacent to field the one their kid is taking part in in this type of club. One parent was adamant about making sure that their involvement in the tech industry has not influenced their child's interest to take part in a technology centered club. Some attendees came with a friend, some with their siblings, so the social feature of the clubs is quite noticeable too. Even though Buutti Education gave out the "carrot" of a summer job for some attendees, in the interviews one instructor said that most of the attendees attended due to an interest in the topic rather that the possibility of a summer job.

5.4 The Non-formality of the Clubs

Based on this description of features of formal/no-formal/informal education, it can be concluded that the Tiedekoulu and Koodikärpät-kerho operated on a basis of non-formality since the features listed in the Table 4 above correspond the best with the

literature about the subject. In Table 9 there are the two clubs compared to the Table 4's different features.

Table 9. Features in Tiedekoulu and Koodikärpät-kerho

Feature	Tiedekoulu	Koodikärpät-kerho
Level of voluntariness	Voluntary sign-up, voluntary attendance but because the topic changes weekly, attendance is recommended	Voluntary, for the possibility of a summer job 4 times should be attended
Structure	Structured	Unstructured
Sequencings	Sequenced	Non-sequenced
Level of assistance	Assisted (1 instructor for 4-8 attendees)	Assisted (Game development: 3 instructors to 20~50 attendees, Web & Android dev. each: 1 to ~10, Robotics: 5 to 20~50
Evaluation	Not evaluated	Not evaluated
Finalization	Open ended, the next courses of the same topic are mentioned	Open ended, summer jobs are in the same field as the club work
Pace	Teacher and curriculum led, the pace of the students is also taken into consideration	Student led
Motivation	Intrinsic or extrinsic (parents might have influenced)	Intrinsic or extrinsic (parents might have influenced)
Context	Outside of school, takes place in a day care center/place visited occasionally	Outside of school (for participants), takes place at the University/place visited occasionally
Spontaneity	Prearranged	Prearranged times and places, attendance is decided by attendee
Freedom	Supported: the topic of the day is the focus but it is allowed to do an original design.	Very much supported, participants are encouraged to do their own designs. Materials to aid the process are provided.
Freedom of social interaction	A lot of freedom though no cursing, bullying or other negative things should be said. Teacher also requests participants to listen when going over the topic of the day.	Total freedom.
Intentionality of outcomes	Somewhat intentional. Participants have freedom to improvise.	Totally unintentional. Some designs are proposed to the participants but usually they just take inspiration from those.
Measurability	Skills can be shown or shared, no grading.	Skills can be shown or shared, no grading.

The Table 9 above compares the features from the literature to the findings in the study. Tiedekoulu is very well characterized with its non-formality but Koodikärpät-kerho has more informal flavoring to it. Still as per the UNESCO (2012) guidelines and other

sources, Koodikärpät-kerho fulfills the prerequisites of non-formal education with its setting and level of instruction. One factor that could influence this is that the club is geared towards older attendees, mainly people in their teens and as they do not need that much organized instruction as younger kids, it might be preferential for them to be left to their own devices in a structured and still aided situation. In Tiedekoulu's clubs the attendees asked permission to do things like play with the robots they made, there were still sometimes the teachers caught an attendee playing a browser game or trying out other projects in Scratch and then would be implored to get back to work. Some comparisons between the formal education and the non-formal clubs could be noticed in the interviews as well. Some attendees mention that there are technologies like Arduino already used in some schools in CS class, but one high schooler interviewed mentioned that as he was attending a specialized high school track, they had no time for CS in their curriculum. For the attendees who do not get CS education at school, these clubs must feel totally different from "regular" school, even if they call the instructors "teach". In an interview with a Koodikärpät-kerho instructor he mentioned that they were quite aghast about the popularity of the game development and robotics clubs and could not really adjust to the influx of attendees. He said that it felt somewhat bad that they could not give everybody the most guidance possible but during the interviews with attendees they stated that they felt like they got enough help.

5.4.1 Challenges in the Non-formal Clubs

Formal education has tools to use when attendees are misbehaving or not using resources correctly. The nature of having people take part in an educational situation by their own volition does not lend itself to "extra homework" or any other chastisements, not that they are generally needed in any educational contexts. One Tiedekoulu teacher employed some tactics that were quite smart and seemed quite inspired by the formal education training that he had gotten at the local University. He mentioned multiple times during different club gatherings that "Do you remember what happens when you all are sitting by the same small table?" in-lieu of having witnessed the attendees not focusing on the topic at hand when they do gather around one small table, not the big one. This relates to the children being there voluntarily and "paying customers" so there is a heavy emphasis on the teacher to keep it fun for everyone. He also mentioned that it was hard to teach sometimes when the attendees come from such varied backgrounds with tech, one great nick knack of information he bestowed upon the researcher once was that "The most important part is to know how to Google things faster than the students". Of course, this can be a problem in formal education as well but it does get more pronounced when there is no real "class structure" or plans for progression of knowledge. This does lead to a positive thing as well; there is no worry that someone would not perform well in a testing situation since there is no such thing in these types of non-formal after-school clubs.

Some parents of attendees mentioned as well that they felt lucky to find a club like the one their child was attending. One parent described seeing something on Facebook, realizing that the club had not come to Oulu yet, waiting, finding out the club was now in Oulu and then signing their child up for the club. The problems attendees stated in the interviews were related to specific problems, such as the use of a non-preferred IDE in programming or the clubs being too short. The Koodikärpät-kerho's robotics club was so popular that they had many times more attendees as would have been ideal. One instructor interviewed stated that this large amount of participants might be detrimental to the level of teaching that they would like to provide the attendees. Jokingly he mentioned as well that it was hard to run around, up and down the space and check that nothing was on fire and nobody is sauntering their finger.

5.5 Fun That Was Had

For this thesis, fun was not measured, its existence got made note of and then analyzed. There were all sorts of different fun to be had in the clubs observed, just as has been discussed in the paragraphs above with the methods described. Games are prevalent in the doing part of the fun spectrum as well as the motivations for attending the clubs. They were also talked about during the clubs a lot. Attendees together shared their interest with each other as well as some instructors. The researcher was asked frequently as well if they had any consoles or what they played games on by the younger attendees. Literature about fun is usually centered on which tasks are fun, should teachers be fun in the classroom or the productization of fun. These three types of fun have been perceived in the observations and interviews but there was one thing that rose solely from the observations: **fun in a social setting**. As itself, it has not been studied in a non-formal context, the same as non-formal education and fun, but it is clear that the old Finnish saying of "shared joy is double the joy, shared sadness only its half" seems to hold true in this context as well. Once, there was only three kids at a robotics club at Tiedekoulu (usually there were 5-7) and there were two teachers since the other was just about to begin their journey as a teacher at Tiedekoulu. The regular teacher said that it must be very boring for the kids to have as many adults in the room as there are students. The class felt a little more anemic that day since there weren't as many kids as usually but they still managed to have fun: laughing about the thing they managed to build and racing with the built LEGO Mindstorms cars on the floor. In Koodikärpät-kerho, the robotics club had more sociability. There was talk about **memes and games** in the programming labs as well but the majority of the noticeable social fun was had in the robotics club. There was a group of high school aged participants who shared their ideas and designs with each other, which exhibits two types of classified fun: social and task related. Playing exhibited social fun characteristics, most kids played together and the fun that is had then is visible and audible. If the playing was done alone, the person playing usually did nor laugh or exhibit any other markers of fun. Nobody mentioned this in the interviews either.

Teachers can contribute to fun as well. At Tiedekoulu, the teachers joked around with the kids and there were even some running gags, for example what are all the different occupations of one teacher. He sometimes made jokes about being a firefighter, police officer, chef etc. Some of the instructors at Koodikärpät-kerho were close in age with the participants so the instructing was done in a peer like manner, with holding a conversation about ideas and problems. Fun was also "baked" into some activities, for example playing your finished game, controlling a LEGO Mindstorms car of your own design and having races or even social fun with micro:bit voting and asking your own questions. Pedagogical fun was more clearly shown in Tiedekoulu since the relationship between student and teacher was more formal (one teacher (whom the participants called teach: ope in Finnish) and multiple kids with the teacher using curriculum-based methods). The instructors usually joked around with the children and they encouraged the kids to have fun while doing what they did. From all of the observed fun having, pedagogical fun had the clearest, universally laughed at "fun consequences". In Koodikärpät-kerho, the relationship was more informal, a mentor-mentee type of situation where the instructors were seen more peer-like. They still had jokes and fun together with the participants but is characteristically more social fun than pedagogical: there was no "silence, the teacher is talking" kind of vibe when the jokes were uttered.

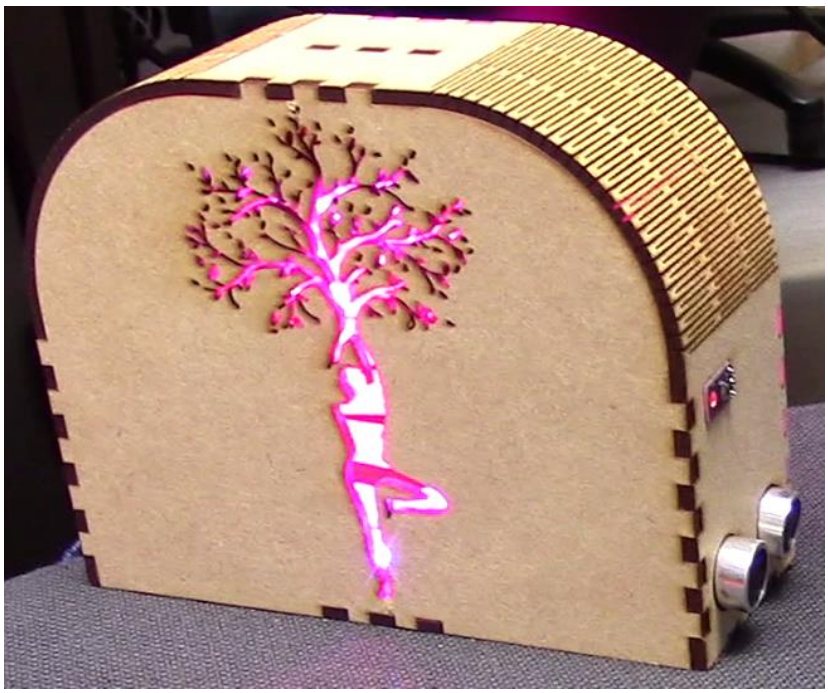
Task related fun is a little more all-encompassing, it is characterized as the fun that was had while designing, building/making/programming and how fun the materials were. The instructions given by the organizations were not inherently fun or funny but some of the materials, like Scratch, LEGO Mindstorms and micro:bit have been characterized as fun

in literature. Freecodecamp.org can be seen as entertaining. This can be seen in the observations as well. Some participants intentionally built “silly” things and showcased them to the other participants while some people felt that it was fun to succeed in something like programming a hard part well enough for the compiler. At points during the study, the researcher wondered why do some of these attendees, who are visibly anxious about their code, come to coding clubs. The answer was cleared up during the interviews: they find the occasional success exhilarating. Success does not express itself with laughter, it has to be asked about to be found.

In all of the occasions memes and talking about games seemed to be a nice way of communal excitation. There was talk about “different skins”, “what games do you play” and citing memes at almost every observed occasion. Also, discussion about popular culture, especially the Finnish TV show “Putous” was popular with children, as well as talking about music. The older teenagers also made stuff from videogames. A game’s logo was put on a key cap, some printed and/or laser cut play-knives from Counter Strike, which can be seen as “fun in doing”. All in all, the non-formality of non-formal education is a good basis for fun. This does not mean that non-formal education is inherently fun, there were a few occurrences when enjoyment was clearly lacking, but it gives fun (and its good influence on learning) a good platform to flower on. There were few negative emotions in the clubs. One interviewee from Koodikärpät-kerho stated that what he would change in the clubs would be “to make them longer”.

5.5.1 Pedagogical Fun

The relationship between Koodikärpät-kerho’s instructors and attendees was more of a mentor-mentee type than the one which teacher’s and with a distinct hierarchical structure. This is why the pedagogical fun does not completely relate to their club structure, there were some aspects there, like **having engaging examples** for what the attendees could do, like the light depicted below. The light’s shell was laser cut, one attendee was observed making a similar style of a lamp but from plastic instead of the wood in the picture. The light inside is of a LED strip that can shine in plethora of different colors and patterns, it is also is controlled by an Arduino Nano, which can have a lot of different properties added onto it, like a movement sensor etc. So the materials given there can be considered as engaging and interesting at the least.



Picture 10. Light that uses both laser cutting and Arduino technologies built by Buutti Education staff.

The pedagogical fun is more pronounced at the Tiedekoulu's clubs where a definite teacher-student relationship could be observed. The teacher was regarded as "teach" by the attendees even. Both of the observed teachers had some jokes that came up and all the attendees went silent in anticipation of the punch line. One thing that can be pedagogically hard is to find the correct or **best suited level of difficulty** for the attendees. One interviewed said that the Koodikärpät-kerho's robotics club is harder than the Arduino things they have gone over at school, but he then said that it is good that it is a bit more difficult. The same interviewee mentioned that he would be interested in attending the club again next year. During the interviews, all of the attendees were more than okay with the level of aid they had gotten from the instructors and teachers. Observations do agree to a point, everybody does get helped, but the noisiest ones who express their disgruntlement the most noticeably usually first. One teacher at Tiedekoulu had as the final lesson a voting system for the micro:bit that the attendees programmed into their devices.

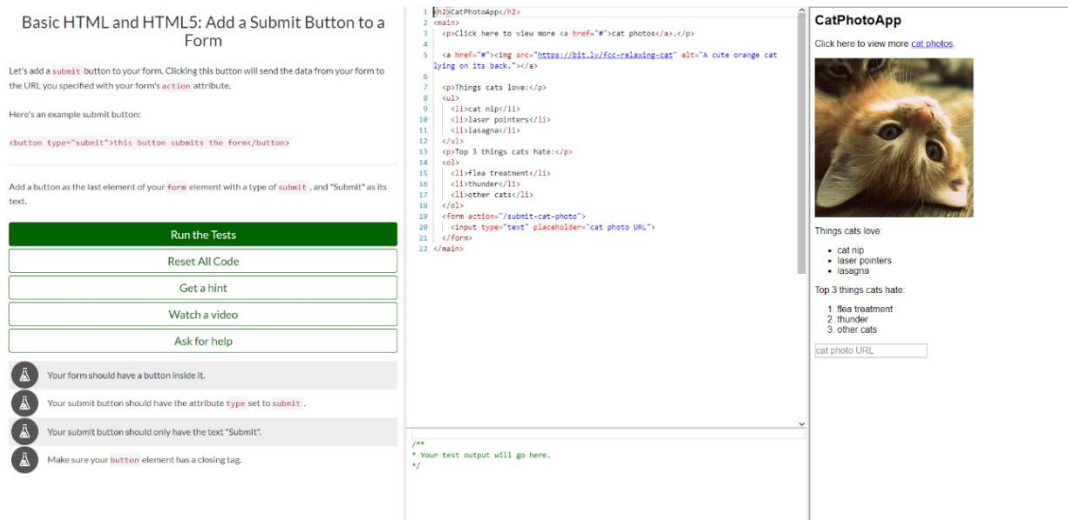
5.5.2 Fun in Doing

Even though programming games and the potential future in that specific field have been stated as a motivation multiple times for attending, still preferential fun can be found in "less fun" seeming things. One child interviewed from the Tiedekoulu's programming club expressed interest in becoming a game developer, found the new and seemingly exciting Python exercises where they practiced its visual elements more fun than the game development linked Scratch -projects. The children drew houses in different colors by changing the colors and tested their logical thinking prowess by changing angles and rotation directions of the lines to form houses. Maybe the novelty of those exercises was interesting compared to the game project they did during the rest of the spring season.

Success as a positive emotion was almost volatile. During the clubs, alarming expressions of frustration were observed. Multiple times in different, especially programming, clubs there were visible and audible groans and annoyed yells, usually after this a teacher or instructor is on their way to the source of the expressiveness. A few minutes later, a silent,

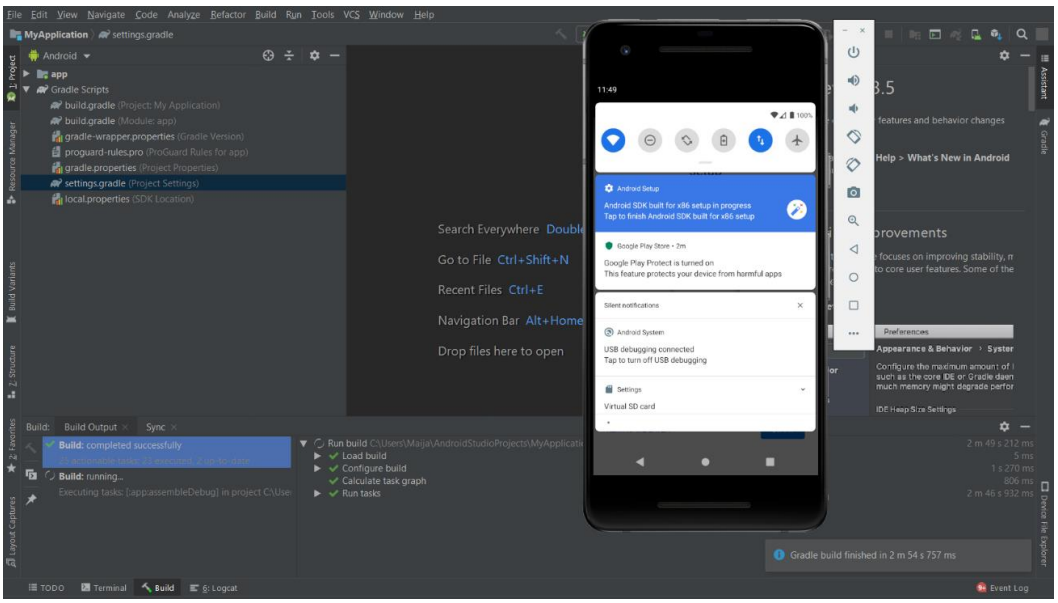
or more audible “Yes!” could be heard. It is clear that something has gone right for the one having the troubles. The researcher was baffled at first, why would somebody attend a voluntary occasion if they had such a bad time in the club. One answer came from the interviews: it was great to get the feeling of success. The exclamation of “Yes!” is the representation of tension in the situation dissolving. One interviewee answered that the best feeling in the clubs was when you got over a challenging part in code or design. Success was not described as fun in the same sense that the English word “fun” describes itself, it was more in the lines of “hauska” a Finnish word that can be described as fun, or more descriptively a feeling of amusement and a little bit of fulfillment. As has been described in past chapters, fun is a multifaceted thing, having multiple different expressions and names. It has been described as a cognitive break, in which’s definition the exclamation of success is included into as well.

Fun in doing is characterized as well with having **entertaining and/or engaging materials**. LEGO blocks are classified as toys in most situations so to use them to teach stuff is genial; they are so clearly designed for children that it is almost gravitational the force the blocks radiate. And to have a curriculum that improves on the engineering and robotics knowledge of the attendees using LEGO bricks is even better. Usually the worst thing about using LEGO is that you have to break down your creation afterwards and that was expressed through the interviews as well. Tic-80 and Unity 3D are high pay-off types of programs to use while learning. With little input, you can already see the work you have made with the visual aspects. The same can be said with micro:bits and LEGO bricks but it is a little different when it is a physical thing that changes its properties or shape. During the interviews, one person mentioned that the initial time he could consider programming fun is when he could see the thing he had done on Tic-80. The pay-off is similar in freecodecamp.org (Picture 11) since it provides the users with a problem to solve, after which you can see a difference in the preview part of the interface like depicted below.



Picture 11. The user interface of freecodecamp.org

Android Studio provides a visual feel to the application you are making, even if you do not have an Android phone right at the moment, there is an emulator where you can test out and do multiple different things to check.



Picture 12. The user interface of Android Studio.

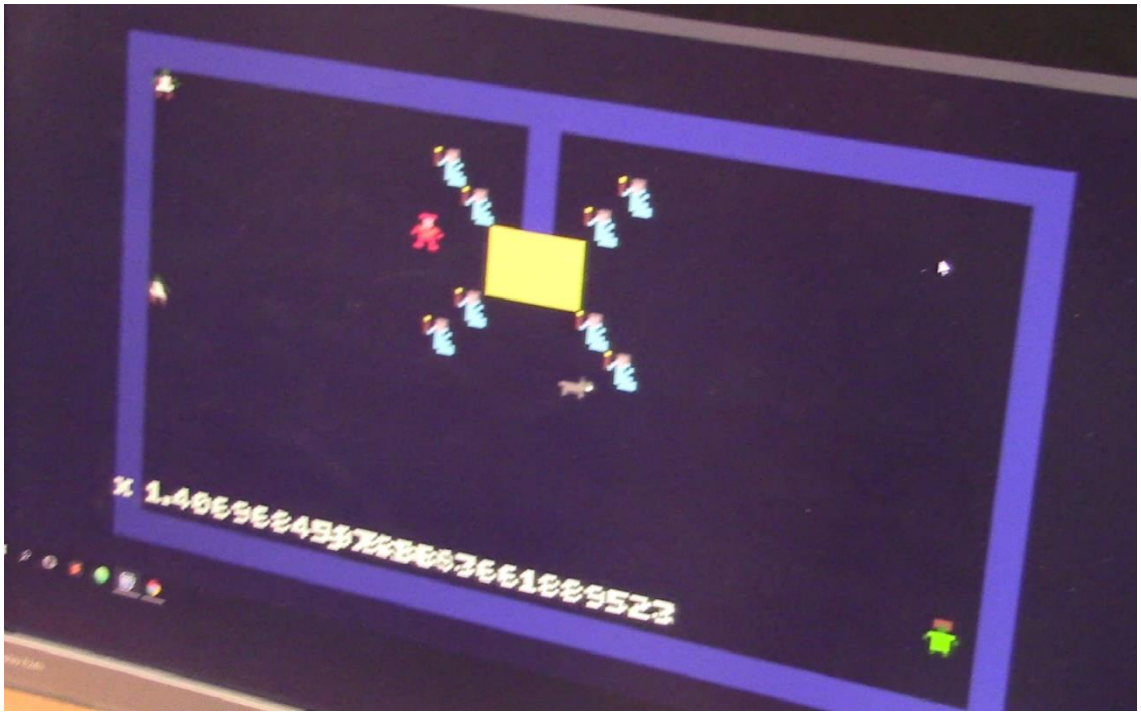
One interviewee described the fun in Koodikärpät-kerho as “it’s fun because you can basically do anything”. The fun in that is translated as **freedom** to do what you please. The interviewer was asking about creativeness while the interview mentioned above was happening but even though it got a positive reaction, there was little to go by as in just nods, no vocal confirmation.

Picture 13. Butterfly knife from a videogame made by laser cutting by an attendee.

The butterfly knife depicted above in Picture 13 did raise some questions from the researcher during the observations. There were multiple people doing knives and other things that seemed not suitable for young people, but the instructors were still extremely helpful with their design and the making of them. Of course, the knives could not be used to harm people but for the researcher it did raise some questions about accepting violent interests. It was clear that the fascination with the knives was authentically aesthetic and for “fun”. The researcher’s little brother is around the same age as some of the observed

and for the researcher, it seems like a good fit for young people to explore these things in a safe and monitored environment. This leads to the question of freedom as well. Is freedom to do what you want fun too? It was not mentioned in the literature part of this thesis, but it seems an interesting thing to study. The freedom to do whatever you want can be considered fun in doing via "fun materials" but does seem linked to creativity.

Programming the Arduino and the LED strips was described as fun. Some ideas for projects arose from jokes, for example the "Shreek" -game discussed further on started as a joke drawing of Shrek, the titular character from the popular movie series, and the idea for a donkey herding game rose from there and through multiple iterations. They described the work there half way between serious work and play, the serious part is when they are finding online aid or resources and the fun is making practical jokes on each other and even the making of the game. The funniest part of that according to one of the pair interviewed was messing around with the code and finding out what happens. The picture below is of the "Shreek" –game, the name is because the developers "did not want to get sued".



Picture 14. Shreek game made by Koodikärpät-kerho's game development club attendees..

The interfaces and the fun factor are linked through the **immediacy of the reward** of success as well as the different types of enjoyment that can be brought upon by designing own sprites, playing and testing your own game and by programming itself. The "Shreek" game in Picture 14 looks like fun and the attendees programming it seemed to have fun as well, but it is tougher to discern which parts of it are the most fun.

5.5.3 Social Fun

Talk of popular culture such as video games, television shows and music was quite usual, even between the attendees and instructors. In the Koodikärpät-kerho's clubs the relationship between attendees and instructors was a little looser and less formal so the "fun" interactions there can be more solidly considered social fun. For example one instructor was aiding people with 3D printing and talked about the design that was being printed on the key cap. The talking went from the shooter game (which was source of the

inspiration for the key cap) to BB guns that the instructor had customized to look like another game's weapon by 3D printing new parts to it, so called "skins" for real-life videogame bb guns.

Social fun was the **sharing of interesting resources and ideas, for one**. The researcher sat down besides two Koodikärpät-kerho's game programming club attendees and listened for a while when they were doing their "Shreek" game with Tic-80. Alone programming tends to be in the lines of programming, search for the solution for a problem, code more until you find another problem, maybe design some sprites or elements once in a while but together it is more complex and reactive. The two observed attendees were making a "Shreek" dance game, they had different sprites and mechanics and while making them, they searched the internet for inspiration. While sat there, the two were laughing, making jokes and friendlily causing each other trouble. The game had gone through multiple design iterations, all seemed interesting, but the final version of a dance game was done because they had managed to make a good collision system. The type of fun that they had could not have been had alone, sure they could have had a great and entertaining time, but the expressions of amusement like laughter and smiling probably would not have happened and thus not observed. The game is depicted above in picture 12.

One other way sharing was observed was that some designs and ideas, like **using videogame-based designs as cores** for different projects, were discussed and sometimes shared with others. The possibility that some things were the products of inspiration from others' works is high as well. It is not clear to the researcher who is around a decade older than the club attendees if for example Counter Strike (a popular game in my youth) has a lot of popularity nowadays still and therefore was a popular motif or if it was a shared interest inside the group observed. The photo above of a butterfly knife was inspired by the game and was previously made with a 3D printer but apparently the laser cut one had more mobility and was therefore more fun to play with.

Sometimes the **fun that was had together came from an individual's own fun**, like for example this one attendee at Tiedekoulu's robotics club named his projects in a very funny way. The other children did not react to it too much, but the teacher and the researcher as well were laughing about it and when the kid's parent came to take him home, they laughed at the names as well. The projects were named "kakkakokkare" and "kakkakokkare2", for example, and to translate "pooppile" or "pieceofpoop". The teacher usually advised attendees not to use profanities in the names of their projects, but this did not seem to violate that rule. Other times it was observed for the teacher to instruct not to name the projects, for example, "paska" which translates to "shit", so poop, as it is a more "kid friendly" word, was allowed.

Social fun was sometimes **unreciprocated**. There were times during the observations when somebody said something that could be perceived as fun, but it did not resonate with the other attendees. For example, humming a fun song or a tune did not get any laughs even though it was visibly geared to other people. This was observed by the researcher only a few times and it was characterized with having the participant looking around for reciprocation. Fun alone could not be that much observed since Finns are a little less emotive than most people groups. If there was fun that was had alone observed, it would be the unreciprocated type mentioned above as it did have an expression and it was not related to the process and procedure of the clubs.

At times, social **fun could be distractive**. Maybe its function as a cognitive break is useful but sometimes it led to attendees not doing what they came to do and instead they

fooled around on the computer or with other stuff. This happened in both instances, Koodikärpät-kerho as well as Tiedekoulu mostly during programming clubs. It is not necessarily bad, as the participation is completely voluntary and breaks in between intense learning and creating are important, but it is worth a mention in this thesis. In Koodikärpät-kerho's game programming club, two attendees that were making the game together said that they usually took breaks during the clubs to take a walk and think about their design. The fun they had when looking for inspiration for their sprites also derailed sometimes and they started to focus on making practical jokes on each other. In Tiedekoulu, the game programming club was also prone to distractions as some participants were observed playing Scratch for most of the club's time. The teachers there usually mentioned that maybe it is enough plying now, if they had noticed someone not making their own project and instead playing other people's creations on the site. This sometimes spread like spitfire; when another attendee noticed how fun the game some other attendee was playing; they would ask the name of the game and start playing that instead of developing their own. This resulted in sharing high scores and/or discussing which level they were stuck on.

6. Discussion

The topic of this thesis is somewhat novel since the topic of "fun in non-formal technology education" has not been studied in the field of HCI previously. Literature in relation to the topic is mainly of practices in non-formal education and its impact on learning, fun as a product or a teaching method and what non-formal education means. This thesis has looked at fun in many different ways, managing to synthetize new approaches to fun in non-formality as well as looked at its context. The linear nature of formality in education was studied with its different practices. The research questions investigated in this study are:

RQ1: What are the practices of non-formal education in Oulu?

RQ2: What are the characteristics of the non-formality of the clubs in this study?

RQ3: How fun is shown and had in the clubs?

They are discussed in the following paragraphs in depth but it is to be stated that due to the nature of this study being exploratory, the research questions were considered while the study was performed or after rather than before. The research questions themselves did not solely rise from the previous literature but they were heavily influenced by the data already gathered and the needs, the COM'n'PLAY SCIENCE –project. The project's Research Instruments and Tools –manual (2019) states as its objectives multiple things but the two main ones this thesis aims to "*Identify, pool and analyse diverse existing coding, making and play-based practices taking place outside formal science classrooms which bear some promise for informal science learning. Conduct in-depth learner-centred participatory empirical research on selected practices."*(COM'n'PLAY SCIENCE, 2019, p 2)

6.1 Practices Present

The literature that is at the basis of RQ1 is from studies that look at non-formal education and from there, elements that describe the things that are done, used and how the organizational aspects of the education are handled. The Tiedekoulu's clubs took place in a daycare center which was not a location discussed in the literature. It does, however, fall into the category of "places we visit occasionally" for the ones attending the clubs, so as per Eshach (2007) who lists those as a places for non-formal education. Koodikärpät-kerho's clubs took place at the university of Oulu, which as a place of higher education and research is well represented in the studies but not in the way that would be preferred.

The clubs took place in the evening and as mentioned, at very similar times, 4 pm. to 7 pm. for Koodikärpät-kerho and 5, 6 or 7 pm. to 8 pm. On Tuesdays, both clubs of Koodikärpät-kerho (robotics and programming) as well as Tiedekoulu's three (2 robotics and one programming) clubs took place, Wednesdays only Tiedekoulu's robotics and programming clubs and finally on Thursdays Koodikärpät-kerhos and Tiedekoulu's robotics clubs. There was no literature about how the time of the day or week influences learning or club attendance, so it is hard to say if these times are typical or not well suited for such activities.

From the literature it is clear that the way non-education is handled is more instructional and less lecturing (Eshach, 2007). In Koodikärpät-kerho, one instructor told in an interview, that they try to have the attendees answer their own problems rather than to

give it to them straight away. The same could be observed in the Tiedekoulu's clubs, for example when the teacher asks an attendee about which part should go there and pointing out something in the code and asking if there was something wrong there. The competencies of the teachers in this thesis were different but all instructors interviewed strived for the attendees to have the best time possible in the clubs. Bar-El and Zimmerman (2016) and Francis (2012) mention that it is easier for attendees to ask for help if they know the instructor or share similar interests. Some instructors in Koodikärpät-kerho were genuinely interested in what they were doing and it was easy to see that the attendees could pick up on that.

Fischback and Lee (2017) looked at how time gets spent in non-formal Maker culture related activities and they noted that material acquisition was universally the most time consuming part of the club. That could be noticed as well in the robotics clubs observed. When it came to LEGO Mindstorms, it was apparent that around half of the hour was spent on getting the correct bricks for the day's lesson and dismantling the projects in Tiedekoulu's robotics clubs. Throughout the other half, some pieces were picked and searched for if they were noticed to be missing so the part about material acquisition taking precedence is true. For the other robotics club at Koodikärpät-kerho it is very hard to say what took the most time and what was the most frequently employed technology. There almost always was a line to the 3D printer but that can be because the printing usually took more time than for example laser cutting. There were some attendees that mainly focused only on one area that was available for them, the ones who programmed the LED strips via Arduino mainly worked on their projects in the Protopaja without much leaving it. They did embark on some other stuff as well; some attendees were seen doing their homework in there so the time was not completely devoted to the tasks that were instructed. This was explained using a different example in the results chapter. There was no literature about how time gets spent in non-formal programming clubs. There were a few different records in the results and the main message of them was that some people concentrate fully to the subject at hand and some partly. The instructors at Koodikärpät-kerho were not seen chastising participants to do what they came to the club to do but in Tiedekoulu, the teachers sometimes prompted the attendees to switch to their own project or to focus on programming instead of creating the same sprite for most of the club's time. Cain and Lee (2016) state that people prefer to do different things based on measuring electrodermal activity in a Makerspace activity. During the observations it was clear that some attendees preferred to do things a little differently and preferred different activities but the interviews stated mostly that the attendees liked the tasks they were doing in the clubs most, some mentioned social aspect and freedom to do what they wanted. The bottom line is that the attendees were originally, before attending the clubs, usually reported to have interest in the field, which narrows the diversity of samples. If someone who had a hobby of crocheting was asked about game programming, the results might be a bit different but since initially every attendee had an interest in the field, the tasks given for them to perform suited them more likely.

Eisenberg in 2013 made a list of technical challenges of 3D printing for children. They are *"(a) expanding the range of physical media available for printing, (b) incorporating ideas derived from ''pick-and-place'' mechanisms into 3D printing, (c) exploring methods for creating portable and ubiquitous printing devices, (d) creating tools for hand-customization and finishing of tangible printed objects, and (e) devising software techniques for specifying, altering, and combining 3D elements in the context of printing*." (Eisenberg, 2013, p. 8) In 2015, these problems were looked at by Iversen, Smith, Blikstein, Katterfeldt and Read and they found that these problems are yet to be addressed. The work Buutti Education does with Koodikärpät-kerho is interesting and even though not all of the challenges are solved, they are addressed in the clubs. The

range of media is large and due to Fusion 360's ease of use, well within reach. There were perfect replicas of game logos made in 3D and even though Thingiverse was not in heavy use, there were inspirations derived from there. Also, hand customization was used a lot, the filing down of harsh surfaces or painting over designs to get the wanted effect.

The Tiedekoulu's clubs followed a curriculum so their projects were mostly the same as everybody else's, there were some variation and the teachers encouraged the attendees to experiment and try out other things besides the ones in the laminates or the instructional website. The technological materials used in the clubs were explained in the previous literature in 2.5.2 – 2.5.4. The literature did not talk about how instructions themselves could influence the learning except for Berk (1996) who mentioned that pedagogical fun can present itself in instructional materials as well.

In Koodikärpät-kerho there was almost absolute freedom to do what ever inspired them. In the robotics club different lamps and lights utilizing the LED strip and an Arduino were the most popular according to both observations and interviews which lined up nicely with Fischback and Lee's (2017) study about how time gets spent in non-formal Maker programs. One of the projects in their study was the LED lightbox, which was similar to the LED lamps that were popular in the Koodikärpät-kerho. The coding that Fishback and Lee (2017) have for their tasks does not reflect what happened in Koodikärpät-kerho since in the paper they described a timetable and instructions and in the observations for this thesis, everything was much more free. Time spent designing the artefacts was much more prevalent in Koodikärpät-kerho but as Alekh et al. (2018) recommend, the tasks were kept short and concise in both occasions, especially if the Koodikärpät-kerho attendee used rapid prototyping like one of the instructors described in an interview. The "short and sweet" tasks were successfully implemented in Tiedekoulu's robotics clubs but in the programming ones, the long Scratch game project got to some attendees. For most of the observations done there, the programming clubs were doing their Scratch game (equates to around 5 hours) and some attendees, how ever interested in game programming, became bored of it.

6.2 Apparent and Interviewed Non-formality

The framework to examine the non-formality of the clubs was done solely based on literature. There were some problems with that though, for example the education system in Finland differs a lot from the qualities formal education is given by Eshach, 2007 and Hofstein and Rosefeld, 1996. The Finnish education system is not as teacher centered as it is depicted in these studies as typically there is a desire to have the children learn what they need to learn and aid them to do it, not to have a teacher in front of the class lecturing. Based on the UNESCO (2012) guidelines, this study contributes to the study of non-formal education as do some other literature like Barker and Ansorge (2007) who state that the 4-H clubs (which is stated to have a curriculum and perform as an after-school club) they studied belonged in the study of informal education. This does not mean that their definition is wrong, the COM'n'PLAY SCIENCE mission statement itself says as well that informal places, such as clubs and other organized events, are to be investigated during the project, which is by this thesis's definition based on multiple sources incorrect. This leads to the speculation that even in reputable sources and societies the definitions of formal/informal/non-formal are not clear cut and some experts see them totally differently with multitudes of sources as well. One other way to see the informal/non-formal divide is to consider them as intentional and unintentional learning. This was stated in the COM'n'PLAY SCIENCE H2020 proposal and even though the sources for this thesis do not collaborate with that statement, it is a logical conclusion nonetheless.

Based on the literature, Eshach's (2007) characterization of non-formal education is mostly centered on the location where the learning takes place; non-formal education happens in places occasionally visited, like museums and zoos. The UNESCO (2012) guidelines state instead that non-formal education takes place usually in community-based settings, workplaces and civil society organizations. The intersection of these location definitions exists and the definitions do not necessarily rule each other out. It is not to say, that it would be impossible for non-formal education to take place at home or at school either, for example in some situation the learner could not leave their house due to a decease or other health problems and the non-formal education could be brought to them. Eshach (2007) mentions industry as one of these places and it is represented by workspaces in the UNESCO (2012) guidelines. Though this is not what the observed clubs are, industry as in commercial business that Buutti Education and Suomen Tiedekoulu are not "learning at a workspace", this is the closest fit for these organizations. Table 4 expresses the different qualities the two clubs had in relation to the framework put together based on the previous literature. It shows that within non-formal education there still can be a lot of fluidity as is stated by Hofstein and Rosenfeld (1996). Education is and should stay multifaceted and learner centered in non-formal education and based on the curriculum and procedures of formal Finnish education, the non-formality does good to children. It gives them a little more space to express themselves and question what is stated as true. In a bigger picture, formal education is not the same anymore. More and more university courses are online where the learning is almost informal, if it were not for the grades and deadlines.

6.3 Self-reported and Observed Fun

Fun in the non-formal technology education area is lacking majorly as HCI research focuses so much on how a product can be fun and if fun should be a new heuristic metric into usability issues, not the process of having fun and which are its triggers. The previous literature part of this thesis is put together from side notes in papers, pedagogical publications and studies looking at fun as a concept. Therefore, the solid scientific background for this part of the thesis was lacking quite spectacularly. Good thing about fun and the research into it is that it is personal and while theories and data about it in its multiple forms can be recorded and analyzed, fun comes from different stimuli and situations for different people (Cain & Lee, 2016). This was present in the empirical part of the study as well. While some participants were absolutely livid with fun, for example reciting last Saturday's Putous TV show's catch phrases, some attendees would not even react, or they could be seen visibly getting annoyed.

The concept of fun has been quite singularly handled in this thesis based on the different descriptions and names it has been given. Enjoyment, excitement and humor are the different qualities of fun spoken in chapter 3.1 (Cain & Lee, 2016; Hanna et al., 2004; Read, 2012; Stewart & Jordan, 2016) but some other qualities such as pleasure and attraction are looked at as well (Blythe & Hassenzahl, 2003). The definitions connect well with the observations: enjoyment of doing tasks, excitement when a hard bit of code went through the compiler and humor in memes and jokes are good examples of different manifestations and fun. It has been quite hard to scientifically state what fun is since it is such a natural and personal thing, so the empirical part focused on when, how and why the different expressions of fun were present in the clubs as well as directly asking the participants about fun. Shneiderman (2004) and Stewart & Jordan (2016) had the most conclusive answers as to how fun presents itself. Laughter, high-fives, being content and satisfaction are important when it came to observations (Shneiderman, 2004; Stewart & Jordan, 2016) and some methodological aspects such as being familiar to the attendees so they did not shy away from the sight of a researcher (Gibson, 2012) were key in getting

the data applicable for this study. One thing that was also noticeable, fun was useful as a cognitive break (Berk, 1996; Garner, 2006), like for example with the case of the two attendees who made the "Shreek" game. They took breaks so that they could look at their project with renewed eyes and having fun was a part of the programming experience in itself. What was noticed during the observations was that the laughter and smiles were directed usually at some specific things. They were other attendees (when sharing jokes and pop culture related project ideas), enjoyable materials (LEGO Mindstorms is considered fun (Stewart & Jordan, 2016) and instructors can provide instructions and models that are enticing) and teachers cracking jokes. These different types of fun were realized before extensive amounts of literature were read so the search for applicable papers was heavily colored by these findings. They will be discussed more in depth in the following paragraphs.

Fun in doing is colored by the materials used and if the tasks planned are enticing and provide a good level of freedom. Game programming is considered fun and Sim, McFarlane and Read (2006) say that it can be an innate property of Scratch that was widely used by Tiedekoulu's coding clubs as well. Scratch was observed to be fun but at least one attendee saw it as a chore and preferred other programming tasks. Satisfaction is a form of fun and it has a lot to do with tasks and performance. It was observed and found out about in interviews when visible anger released itself as a "yippee" or when an attendee stated that it was fun to get things working. Enough challenge in the task performed is a good thing (Brandtzæg et al., 2003) and that was found in the interviews as well. One interviewee stated that the feeling of having completed something was the most fun, which is linked to fun as a release of pressure that was not found in literature into the topic of this thesis. Social fun as is found in this thesis could not be found from the literature into HCI education. The discussion on this part is limited to the notion of that it can be had as a collective thing (Alekh et al., 2018). Social fun is characterized with sharing amongst peers, like for example cooperating and launching ideas off each other for a game project or by laughing together at memes. These expressions are related to the non-formal nature of the clubs observed as in memes would probably not be tolerated in a formal classroom. Pedagogical fun in this thesis relies heavily on Berk's 1996 paper that lists humorous tactics. From the list given on page 23 of this thesis, humorous material syllabi and in-class spontaneous humor could be seen and heard. At Koodikärpät-kerho the instructors provided visually enticing projects (like in Picture 10) to help attendees decide what they would like to do and in Tiedekoulu's clubs teachers could get the whole group of attendees burst out laughing and this is considered pedagogical humor due to the stricter roles that were assumed by the teachers and students there. In Koodikärpät-kerho the relationship was more loose so it does not belong in this category. In Tiedekoulu's last micro:bit session the teacher held a voting with the attendees using the micro:bit's two buttons, background code from the teacher and code from the attendees to use the voting functionalities on their micro:bits. The whole thing turned out to be hilarious with the attendees given permission to ask their own questions. This seems like a pinnacle of different funs smashed together: fun in doing while programming the micro:bits with the colorful IDE (Picture 4), Berk's (1996) in-class humorous questions and fun interactions with teacher and finally, social fun in asking each other questions about films and television. As Garner (2006) said, humor can bridge the gap between attendees and educators.

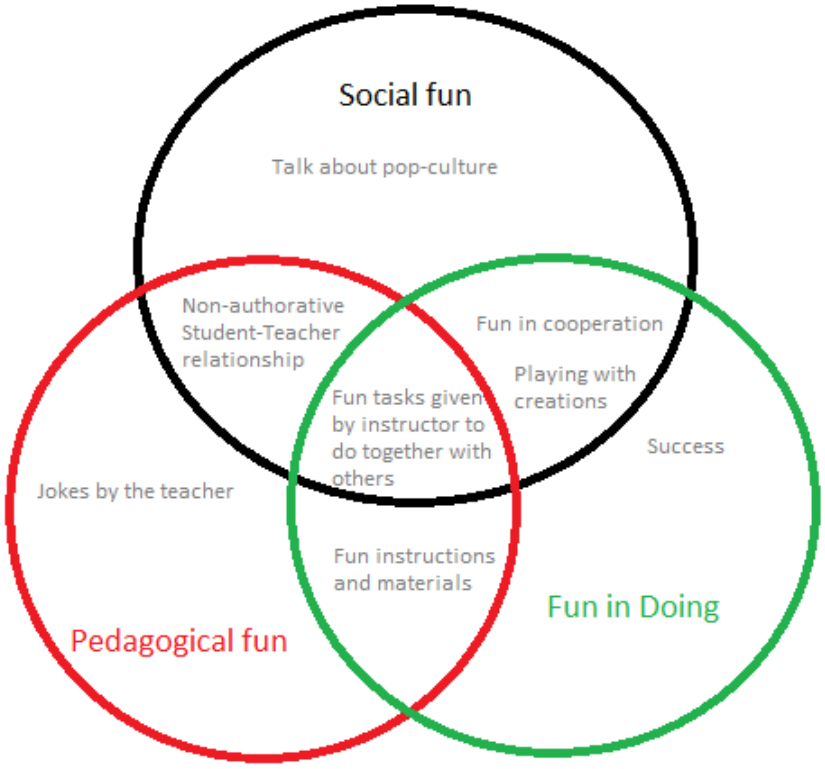


Figure 3. All the different funs together with filled in examples in the diagram.

The small texts in Figure 3 are some examples of manifestations of fun that have arisen from the data. The visualization on how the different funs are had was constructed initially with all of these examples in it and was emptied for Figure 2.

6.4 Freedom, Fun and Formality

Motivation is an integral part of learning that can be reached through play (Draper, 1999). In the observations there have been two targets of motivation in the clubs: the motivation to sign up and to keep going to the club. The voluntariness of an action relies on the motivation of the performer to see the task through and the freedom to attend is one important part of what defines non-formal education (Eshack, 2007). Motivation to start gives good leeway to staying in the club especially if the attendee is genuinely interested in the topic or the new technologies played with in them. One new pattern that has arose from the data is the way non-formality influences fun directly. Freedom to do what ever projects the attendees want has been present in the interviews and in the tables regarding to levels of non-formality, freedom and voluntariness are the most noticeable words due to their prominence on the top of the list or the frequency they are used. Freedom to do whatever you want is fun and non-formality is the good balance between pressure and motivation (social pressure to attend, having paid for the club or wanting to finish a project, for example) and the liberty to choose your own way. Although there are multiple different ways to have fun, as has been discussed in this thesis, freedom is what links fun to the non-formal. Creativity seems important to young people (Ryokai et al.,2009) and what is more creative than being inspired and been given free hands to do as you wish.

7. Conclusion

As it has been stated, previous literature into fun in non-formal education situations is scarce and lacks direction therefore it would be profitable for those associated in the fields of HCI and Education to note the different ways fun can influence the time spent (and enjoyed) in non-formal clubs. The relationship between non-formal education and fun is not clear from this basis but given the "restrictions" of formal education, it can be stated that fun has a freer platform to develop and express itself in the non-formal spaces of the linearity. Also, it is not known if these three types of fun discussed in this thesis are general fun and could be applied to any situation or if the fun is case specific to the study done here. Most likely the answer lays somewhere in between. With qualitative methods and ethical research practices the study for this thesis found that the Koodikärpät-kerho and Tiedekoulu exhibit non-formal educational practices and qualities of which the most descriptive ones are voluntariness of attendance, guided tasks and freedom. Fun has been an integral part of this study. The researcher had fun while attending these different situations and found fun in three different major expressions or targets: fun in doing, social fun and pedagogical fun.

To summarize this thesis, non-formality is the definite mode of education in the Koodikärpät-kerho and Tiedekoulu clubs. The literature describes the formal/informal/non-formal trichotomy as a linear entity that expresses itself as different practices and levels of voluntariness on the behalf of the attendees. This has been reciprocated in this thesis from the viewpoint of non-formal education. The procedures of the clubs were somewhat similar to the ones described in literature. Since research into non-formal STEM education is quite new, the consensus of what goes on in non-formal clubs has not been formed, and reflection on if it even should be prevails. Fun can be had in multiple different ways in these clubs.

The contribution of this thesis for practice is that fun exists in non-formal education either due to its or human nature and should therefore be utilized. Motivation is important when it comes to signing up for a club but to keep the attendees coming back and enjoy what they are doing, fun should be incorporated into the curriculum or given room to blossom. Freedom to choose your topic and share your feelings, jokes, successes and positive experiences provide a nice basis for a fun environment where the different practices of non-formal education can take the wheel in letting the looseness of education come to its full potential. The linearity of formal/non-formal/informal education allows practitioners to spread their foci in education methods so this thesis could provide people involved in formal education aids to help with having fun in the classroom. Some of the challenges investigated in this thesis give guidelines on what to look out for in some non-formal education related situations and possibly how to correct them. The research contribution of this thesis is a horizontal, novel look into how some technology driven clubs function and how they fit into the non-formal education landscape in theory. This thesis has also made a few synthesis about how fun works in non-formal education and how a modernized and Finnified list of non-formal attributes can be implemented in research. The investigation into this topic in the Oulu area of Finland does provide a somewhat applicable picture into the possibilities of non-formal education in other large cities in Finland since the two clubs with all of their similarities had multiple differences (for example Koodikärpät-kerho being free and Tiedekoulu costing around 200 euros per course) so the range within the non-formal box is still quite varied.

7.1 Limitations and Future Implications

Since this look into the non-formal technology education through the lens of fun has been quite horizontal, there are multiple limitations in this work that are either directly linked to the method or the "difficulties of life" so to speak. The use of qualitative methods gives us a good look into "how" and "why" but is not necessarily the best way to measure the adequacies or performance of the pedagogical situations. The added use of quantitative methods could have brought a new level of depth into the research, for example surveys before and after club et cetera. The researcher did not want to influence the natural flow of the clubs so this could have been difficult but some of the attendees were very active and probably could have been responsive to this type of ordeal. Also, some interview aids could be included into the methods, like pictures or memory ques so that the interviews themselves could have had a fun atmosphere to wake up memories of fun. Due to the nature of the clubs, only robotics and programming were looked into. Tiedekoulu provides science clubs as well so for a natural sciences researcher with an interest in sociology or pedagogy could investigate those as well. For non-Finnish people the city of Oulu with around 200 000 inhabitants might seem small but in the scale of Finland, it is the fifth largest city in the country. This implicates that the instances studied here, and their likes might not be applicable outside of the largest cities as well as countries that do not give children as much free time or cultures (both domestic and global) do not encourage learning outside of school. The clubs were held during the afternoons of weekdays and therefore there were bound to be some scheduling conflicts. They were managed fine and no noticeable adverse effects could be seen but this did limit deeper ethnography.

In future research it would be interesting to see how researchers themselves would set up a "lab" like situation where they non-formally taught the attendees something and observed fun in a set up situation. There could be examples of the different fun mentioned in this study in focus or other things that relate to fun, such as different levels of observed engagement connected with surveyed or interviewed feelings of fun. Also, as the locational problems were discussed above, this type of mapping could be done in a wholly different context to Oulu, maybe rural areas and bigger cities. One application for the future that interests the researcher personally would be learning opportunities and technological literacy in the eyes of fun. Memes and pop culture in education would be an extremely important study subject for other reasons and for another field of research.

The data gathered for this thesis is quite surmountable and therefore some further studies about, for example, technologies learned by the attendees and how the learning has happened could be good topics to study for those that are left with the data, the University of Oulu and the INTERACT research unit.

References

Aivaloglou, E., & Hermans, F. (2016). (2016). How kids code and how we know: An exploratory study on the scratch repository. Paper presented at the *Proceedings of the 2016 ACM Conference on International Computing Education Research,* Melbourne, VIC, Australia. 53-61. doi:10.1145/2960310.2960325 Retrieved from http://doi.acm.org/10.1145/2960310.2960325

Alekh, V., Vennila, V., Nair, R., Susmitha, V., Muraleedharan, A., Alkoyak-Yildiz, M., . . . Bhavani, R. R. (2018). (2018). Aim for the sky: Fostering a constructionist learning environment for teaching maker skills to children in india. Paper presented at the *Proceedings of the Conference on Creativity and Making in Education,* Trondheim, Norway. 87-94. doi:10.1145/3213818.3213830 Retrieved from http://doi.acm.org/10.1145/3213818.3213830

Android Studio, https://developer.android.com/studio/intro/, read 28.7.2019

Arduino, https://www.arduino.cc/en/Guide/Introduction, read 30.7.2019

Bar-El, D., & Zuckerman, O. (2016). (2016). Maketec: A makerspace as a third place for children. Paper presented at the *Proceedings of the TEI '16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction,* Eindhoven, Netherlands. 380-385. doi:10.1145/2839462.2856556 Retrieved from http://doi.acm.org/10.1145/2839462.2856556

Barker, B. S., & Ansorge, J. (2007). Robotics as means to increase achievement scores in an informal learning environment. *Journal of Research on Technology in Education, 39*(3), 229-243. doi:10.1080/15391523.2007.10782481

Barker, J. and Weller, S. (2003), "“Is it fun?” developing children centred research methods. *International Journal of Sociology and Social Policy*, Vol. 23 No. 1/2, pp. 33-58. https://doi.org/10.1108/01443330310790435

Berk, R. (1996). Student ratings of 10 strategies for using humor in college teaching. *Journal on Excellence in College Teaching, 7*

Blythe, M. A., Hassenzahl, M (2003) The Semantics of Fun: Differentiating Enjoyable Experiences. In Blythe, M. A., Wright, P. C., Overbreeke, K. & Monk, A. F. *Funology: From usability to enjoyment* (pp. 91- 100). Dordrecht: Kluwer Academic.

Brandtzæg, P. B., Følstad, A. &Heim, J. (2003) Enjoyment: Lessons from Karasek. In Blythe, M. A., Wright, P. C., Overbreeke, K. & Monk, A. F. *Funology: From usability to enjoyment* (pp. 55-65) Dordrecht: Kluwer Academic.

Cain, R., & Lee, V. R. (2016). Measuring electrodermal activity to capture engagement in an afterschool maker program. Paper presented at the *Proceedings of the 6th Annual Conference on Creativity and Fabrication in Education,* Stanford, CA, USA. 78-81. doi:10.1145/3003397.3003409 Retrieved from http://doi.acm.org/10.1145/3003397.3003409

Carroll, J. M., & Thomas, J. C. (1988). Fun. *SIGCHI Bull., 19*(3), 21-24. doi:10.1145/49108.1045604

Colardyn, D., & Bjornavold, J. (2004). Validation of Formal, Non-Formal and Informal Learning: policy and practices in EU Member States 1. *European journal of education*, *39*(1), 69-89.

COM'n'PLAY SCIENCE (2017). Learning science the fun and creative way: coding, making, and play as vehicles for informal science learning in the 21st century. Horizon 2020 project proposal

COM'n'PLAY SCIENCE. (2019) D1.2 COM'N'PLAY SCIENCE RESEARCH INSTRUMENTS AND TOOLS, Public COM'n'PLAY SCIENCE –project Deliverable.

Darbyshire, P., MacDougall, C., & Schiller, W. (2005). Multiple methods in qualitative research with children: more insight or just more?. *Qualitative research*, *5*(4), 417-436.

Delamont, S., (2006). Ethnography and participant observation. In Seale, C., Gobo, G., Gubrium, J. F. & Silverman, D. *Qualitative research practice* (p. 217-229). Los Angeles: Sage.

Denner, J., Campe, S., & Werner, L. (2019). Does computer game design and programming benefit children? A meta-synthesis of research. *ACM Trans.Comput.Educ., 19*(3), 19:1-19:35. doi:10.1145/3277565

Dickson, P. E. (2015). Using unity to teach game development: When you've never written a game. Paper presented at the *Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education,* Vilnius, Lithuania. 75-80. doi:10.1145/2729094.2742591 Retrieved from http://doi.acm.org/10.1145/2729094.2742591

DiSalvo, B., Reid, C., & Roshan, P. K. (2014). (2014). They can'T find us: The search for informal CS education. Paper presented at the *Proceedings of the 45th ACM Technical Symposium on Computer Science Education,* Atlanta, Georgia, USA. 487-492. doi:10.1145/2538862.2538933 Retrieved from http://doi.acm.org/10.1145/2538862.2538933

Eisenberg, M. (2013). 3D printing for children: What to build next? *International Journal of Child-Computer Interaction, 1*(1), 7-13. doi:10.1016/j.ijcci.2012.08.004

Eshach, H. (2007). Bridging in-school and out-of-school learning: Formal, non-formal, and informal education. *Journal of Science Education and Technology, 16*(2), 171-190. doi:10.1007/s10956-006-9027-1"

Epilog, https://www.epiloglaser.com/laser-machines/fusion-laser-series.htm, read 10.11.2019

Finnish Curriculum of Basic Education, Finnish National Agency for Education (2014). Perusopetuksen Opetussuunnitelman Perusteet, *Määräykset ja ohjeet 2014:96*, retrieved from https://www.oph.fi/fi/koulutus-ja-tutkinnot/perusopetuksen-opetussuunnitelmien-perusteet

Fischback, L., & Lee, V. R. (2017). How time gets used in afterschool maker programs. Paper presented at the Proceedings of the 7th Annual Conference on Creativity and Fabrication in Education, Stanford, CA, USA. 11:1-11:4. doi:10.1145/3141798.3141810 Retrieved from http://doi.acm.org/10.1145/3141798.3141810

Flyvberg, B., (2006). Five misunderstandings about case-study research. In Seale, C., Gobo, G., Gubrium, J. F. & Silverman, D. *Qualitative research practice* (p. 420-434). Los Angeles: Sage.

Francis, M. (2013). Using Fun to Teach Rigorous Content. *Communications in Information Literacy, 6* (2), 151-159. https://doi.org/10.15760/comminfolit.2013.6.2.125

Freecodecamp.org, https://about.freecodecamp.org/, read 28.7.2019

Fusion 360, https://www.autodesk.com/products/fusion-360/features, read 30.7.2019

Garner, R. L. (2006). Humor in pedagogy: How ha-ha can lead to aha!. *College Teaching*, *54*(1), 177-180.

Gibson, J. E. (2012). Interviews and focus groups with children: Methods that match children's developing competencies. *Journal of Family Theory & Review, 4*(2), 148-159. doi:10.1111/j.1756-2589.2012.00119.x

Grover, R., Krishnan, S., Shoup, T., & Khanbaghi, M. (2014). A competition-based approach for undergraduate mechatronics education using the arduino platform. Paper presented at the *Fourth Interdisciplinary Engineering Design Education Conference,* 78-83. doi:10.1109/IEDEC.2014.6784685

Hanna, L., Neapolitan, D., & Risden, K. (2004). Evaluating computer game concepts with children. Paper presented at the *Proceedings of the 2004 Conference on Interaction Design and Children: Building a Community,* Maryland. 49-56. doi:10.1145/1017833.1017840 Retrieved from http://doi.acm.org/10.1145/1017833.1017840

Hofstein, A., & Rosenfeld, S. (1996). Bridging the gap between formal and informal science learning. *Studies in Science Education, 28*, 87-112.

Horn, M. S., Solovey, E. T., Crouser, R. J., & Jacob, R. J. K. (2009). Comparing the use of tangible and graphical programming languages for informal science education. Paper presented at the *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems,* Boston, MA, USA. 975-984. doi:10.1145/1518701.1518851 Retrieved from http://doi.acm.org/10.1145/1518701.1518851

Inkscape, https://inkscape.org/about/overview/, read 30.7.2019

Iversen, O. S., Smith, R. C., Blikstein, P., Katterfeldt, E., & Read, J. C. (2015). *Digital fabrication in education: Expanding the research towards design and reflective practices* doi:https://doi-org.pc124152.oulu.fi:9443/10.1016/j.ijcci.2016.01.001 "

Krishnamurthi, A., Bevan, B., Rinehart, J., & Coulon, V. R. (2013). What Afterschool STEM Does Best: How Stakeholders Describe Youth Learning Outcomes. *Afterschool Matters*, *18*, 42-49.

Kuula, A. (2011). *Tutkimusetiikka: Aineistojen hankinta, käyttö ja säilytys*. Tampere: Vastapaino.

LEGO Mindstorms, https://education.lego.com/en-us/middle-school/intro/mindstorms-ev3, read 20.11.2019

LEGO Education Simple & Powered Machines. https://education.lego.com/en-us/middle-school/intro/simple-powered-machines, read 20.11.2019

Malan, D. J., & Leitner, H. H. (2007). Scratch for budding computer scientists. *SIGCSE Bull., 39*(1), 223-227. doi:10.1145/1227504.1227388

Maloney, J., Rusk, N., Burd, L., Silverman, B., Kafai, Y., & Resnick, M. (2004). (2004). Scratch: A sneak preview. Paper presented at the *Proceedings - Second International Conference on Creating, Connecting and Collaborating through Computing,* 104-109. doi:10.1109/C5.2004.1314376

Maloney, J. H., Peppler, K., Kafai, Y., Resnick, M., & Rusk, N. (2008). Programming by choice: Urban youth learning programming with scratch. *SIGCSE Bull., 40*(1), 367-371. doi:10.1145/1352322.1352260

Merkouris, A., Chorianopoulos, K., & Kameas, A. (2017). Teaching programming in secondary education through embodied computing platforms: Robotics and wearables. *ACM Trans.Comput.Educ., 17*(2), 9:1-9:22. doi:10.1145/3025013

micro:bit Code, https://microbit.org/fi/code/, read 1.8.2019

micro:bit Features, https://microbit.org/fi/guide/features/, read 1.8.2019

Nielsen J., (2003) User Empowerment and the Fun Factor: Questions and Answers with Jacob Nielsen. In Blythe, M. A., Wright, P. C., Overbreeke, K. & Monk, A. F. *Funology: From usability to enjoyment* (pp. 103-105). Dordrecht: Kluwer Academic.

Overbeeke, K., Djajadiningrat, T., Hummels, C.,Wensveen, S. & Frens, J., (2003) Let's Make Things Engaging. In Blythe, M. A., Wright, P. C., Overbreeke, K. & Monk, A. F. *Funology: From usability to enjoyment* (p. 7- 17). Dordrecht: Kluwer Academic.

Papavlasopoulou, S., Giannakos, M. N., & Jaccheri, L. (2017). Empirical studies on the maker movement, a promising approach to learning: A literature review. *Entertainment Computing, 18*, 57. doi:https://doi.org/10.1016/j.entcom.2016.09.002"

Pink, S., (2006). Visual methods. In Seale, C., Gobo, G., Gubrium, J. F. & Silverman, D. *Qualitative research practice* (p. 391-406). Los Angeles: Sage.

Pink, S., & Morgan, J. (2013). Short-term ethnography: Intense routes to knowing. *Symbolic Interaction, 36*(3), 351-361. doi:10.1002/symb.66

RAISE3D, https://www.raise3d.com/pro2/, read 10.11.2019

Rapley, T., (2006). Interviews. In Seale, C., Gobo, G., Gubrium, J. F. & Silverman, D. *Qualitative research practice* (p. 15-33). Los Angeles: Sage.

Read, J. C., MacFarlane, S., & Casey, C. (2002, August). Endurability, engagement and expectations: Measuring children's fun. In *Interaction design and children* (Vol. 2, pp. 1-23). Eindhoven: Shaker Publishing.

Read, J. C., & MacFarlane, S. (2006). Using the fun toolkit and other survey methods to gather opinions in child computer interaction. Paper presented at the *Proceedings of the 2006 Conference on Interaction Design and Children,* Tampere, Finland. 81-88. doi:10.1145/1139073.1139096 Retrieved from http://doi.acm.org/10.1145/1139073.1139096

Read, J. C. (2012). Evaluating artefacts with children: Age and technology effects in the reporting of expected and experienced fun. Paper presented at the *Proceedings of the 14th ACM International Conference on Multimodal Interaction,* Santa Monica, California, USA. 241-248. doi:10.1145/2388676.2388727 Retrieved from http://doi.acm.org.pc124152.oulu.fi:8080/10.1145/2388676.2388727

Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., . . . Kafai, Y. (2009). Scratch: Programming for all. *Commun.ACM, 52*(11), 60-67. doi:10.1145/1592761.1592779

Ryen, A., (2006) Ethical issues. In Seale, C., Gobo, G., Gubrium, J. F. & Silverman, D. *Qualitative research practice* (p. 230-247). Los Angeles: Sage.

Ryokai, K., Lee, M. J., & Breitbart, J. M. (2009). (2009). Children's storytelling and programming with robotic characters. Paper presented at the *Proceedings of the Seventh ACM Conference on Creativity and Cognition,* Berkeley, California, USA. 19-28. doi:10.1145/1640233.1640240 Retrieved from http://doi.acm.org/10.1145/1640233.1640240

Scratch statistics, https://scratch.mit.edu/statistics/, read 25.7.2019

Sentance, S., Waite, J., Hodges, S., MacLeod, E., & Yeomans, L. (2017). (2017). Creating cool stuff: Pupils' experience of the BBC micro:Bit. Paper presented at the *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education,* Seattle, Washington, USA. 531-536. doi:10.1145/3017680.3017749 Retrieved from http://doi.acm.org/10.1145/3017680.3017749

Sharma, K., Papavlasopoulou, S., & Giannakos, M. (2019). Joint emotional state of children and perceived collaborative experience in coding activities. Paper presented at the *Proceedings of the 18th ACM International Conference on Interaction Design and Children,* Boise, ID, USA. 133-145. doi:10.1145/3311927.3323145 Retrieved from http://doi.acm.org/10.1145/3311927.3323145

Sim, G., MacFarlane, S., & Read, J. (2006). All work and no play: Measuring fun, usability, and learning in software for children. *Computers and Education, 46*(3), 235-248. doi:10.1016/j.compedu.2005.11.021

Scratch, https://scratch.mit.edu/, read 7.6.2019

Shneiderman, B. (2004). Designing for fun: how can we design user interfaces to be more fun?. *interactions*, *11*(5), 48-50.

Stewart, O. G., & Jordan, M. E. (2017). “Some explanation here”: A case study of learning opportunities and tensions in an informal science learning environment. *Instructional Science, 45*(2), 137-156. doi:10.1007/s11251-016-9396-7

Sullivan, F. R. (2008). Robotics and science literacy: Thinking skills, science process skills and systems understanding. *Journal of Research in Science Teaching, 45*(3), 373-394. doi:10.1002/tea.20238

Tic-80 Github, https://github.com/nesbox/TIC-80/wiki, read 25.7.2019

Tisza, G., Papavlasopoulou, S., Christidou, D., Voulgari, I., Iivari, N., Giannakos, M. N., Kinnula, M., Markopoulos, P. (2019a). The role of age and gender on implementing informal and non-formal science learning activities for children. Paper presented at the *Proceedings of the FabLearn Europe 2019 Conference,* Oulu, Finland. 10:1-10:9. doi:10.1145/3335055.3335065 Retrieved from http://doi.acm.org/10.1145/3335055.3335065

Tisza, G., Gollerizo, A., & Markopoulos, P. (2019b). Measuring fun with adolescents: Introducing the spanish and dutch adaptation of the FunQ. Paper presented at the *Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts,* Barcelona, Spain. 715-722. doi:10.1145/3341215.3356265 Retrieved from http://doi.acm.org/10.1145/3341215.3356265

UNESCO (2012). UNESCO guidelines for the recognition, validation and accreditation of the outcomes of non-formal and informal learning. Hamburg: UNESCO Institute for Lifelong Learning. (citation?)

Unity 3D Made With, https://unity.com/madewith, read 25.7.2019

Unity 3D Space Chicken, https://learn.unity.com/project/space-chicken, read 25.7.2019

Ventä-Olkkonen, L., Lanamäki, A., Iivari, N., & Kuutti, K. (2016). Using with discretion: Identifying emergent practices around interactive public displays. Paper presented at the *ECIS 2016 Proceedings*

Walsh, L. (2014). Informal science learning in the formal classroom. *Science and Children, 51*(9), 54-58.

Wardrip, P. S., & Brahms, L. (2015). (2015). Learning practices of making: Developing a framework for design. Paper presented at the *Proceedings of the 14th International Conference on Interaction Design and Children,* Boston, Massachusetts. 375-378. doi:10.1145/2771839.2771920 Retrieved from http://doi.acm.org/10.1145/2771839.2771920

Weibert, A., Sprenger, M., Randall, D., & Wulf, V. (2016). Lifecycles of computer clubs: Rhythms and patterns of collaboration and learning in an intercultural setting. Paper presented at the *Proceedings of the 19th International Conference on Supporting Group Work,* Sanibel Island, Florida, USA. 137-147. doi:10.1145/2957276.2957306 Retrieved from http://doi.acm.org/10.1145/2957276.2957306

Appendix

List of Questions from the COM'n'PLAY SCIENCE Tools and Methods Deliverable 1.2.

[Participants own description of the activity and their participation]

- What did you do in the activity?
- Did you enjoy it? What was fun/interesting? What was not/less fun?
- Did you learn something new? What? How/when do you think your new knowledge can be used?

[Relation to formal education]

- Was this different from what you (usually) do/learn in school? How?
- Do you think what you learnt will help you do better in school? How?

[Contribution towards scientific citizenship]

- How could you use what you did here in the future?

[Attitudes]

- Would you like to do something like this again?
- Would you recommend/tell a friend to go to this activity? What would you tell your friend about it?
- Would you like to have a job where you do something like this when you grow up? What would you do?

[Perception of the activity]

- Was there something hard about what you did?
- What was the easiest part of the activity for you? How/Why?
- Was there some frustrating/irritating part of what you were doing?
- If you were to suggest how the activity could become even better, what would you say?

How did you get involved in this activity?

Could you tell me briefly what do you do?

How long have you been involved in this activity?

What type of education or training, if any, do you have as a background?

What motivates you to engage in these activities? Why do you want to do this?

How would you characterize people like yourself and what you do?

Could you describe what happens in your (typical, recent) activity/project? Please describe all the participants involved (adults and children): children's ages, group size, how they become participants, adults' roles

Please describe the space, and the materials and tools used

Can you tell me a little bit more about why you do it like that?

Do you think the activities are "fun" or "playful"?

How important is fun in the activities?

How important is playfulness in the activities?

If applicable: why do you experience the activities as fun?

If applicable: why do you experience the activities as play(ful)?

What do you like/enjoy most during the activity?

What are the main difficulties/issues/challenges you face? Can you tell me how you have tried to resolve these?

What do you think is the easiest part in the activity?

What frustrates you the most in the activity?

What impresses you the most in the activity?

Do you learn collaboratively? Do you feel that you are actively part of collaboration in the team during the process? How do you feel about the collaboration in your team?

How much do you think you contribute in the team/do you feel that your opinions are taken into account by the team members?

What do you think you learn during the activity? What do you gain through participating in this activity?

[Facilitator's own description of the activity and their role in it]

- What did the participants do in the activity?
- Do you think they enjoyed it? What was fun/interesting? What was not/less fun?
- Do you think they learned something new? What? How/when do you think their new knowledge can be used?

[Relation to formal education]

- Do you think this is different from what the participants (usually) do/learn in school? How?
- Do you think what they learnt will be useful for them in school? How?

[Contribution towards scientific citizenship]

- Do you think what they learnt will be useful in their everyday life? How?

[Attitudes]

- Do you think they would like to participate in more/other activities of this kind?
- Do you think they would recommend/tell a friend to go to this activity? What do you think they might say to their friend about it?
- Do you think that the activity could have had an impact on participants' future career aspirations?

[Perception of the activity]

- Did you get suggestions on how the activity could be improved, what did they say? What do you think about the suggestions?

1. What is your personal story? How did you get involved in this? Key aspects to approach:

- Could you tell me briefly what do you do with the young people/Europeans? What is your role in these activities?
- About your background
    - Have you worked in a similar field previously?
    - What type of education and training has prepared you for your current work?
    - What motivates you to engage in this form of work? Why do you want to do this?

2. What is unique in what you do, compared to formal science education? Key aspects to approach:

- Where do you place your organisation/activities in the context of the broader educational system (which might include schools, faith groups, holiday activities, and so on)?
- How would you characterize people like yourself and what they do?
    - Is there something different or unique about your work compared to formal science education?
- If someone were to ask you what is particularly special about practitioners working in a similar way to you (ie outside of the school context...) how would you answer them?
    - What makes you say that?

3. Can you describe what happens in your (typical, recent) activities? (if respondent doesn't know where to start, prompt with: choose your favourite/most popular activity) Key aspects to approach:

- Please describe all the participants involved (adults and children): children's ages,
- group size, how they become participants, adults' roles
- Please describe the tools used
- Do you mix ages during the activities? Can you tell me a little bit more about why you do it like that?
- Do the participants learn collaboratively?
- How can you relate these activities to formal education?
- What do you hope that children get from taking part in this activity?
- Why do you think they participate?
- Do you do things differently from others working in this field? In what ways?

4. There are two terms that are frequently used in combination with informal science learning. Fun and play(ful(ness)). Would you say that your activities are "fun" or "playful"? Key aspects to approach:

- Do you think of your activities as "fun" or "playful"?
- How important is fun in the way you set up your activities?
- How important is playfulness to the way you set up your activities?
- If applicable: What convinces you that participants experience the activities as fun?
- If applicable: What convinces you that participants experience the activities as play(ful)?
- Do you think that fun and playful attributes are important to achieving your desired vision/outcomes?

5. What are the main difficulties/issues/challenges you face? Key aspects to approach:

- Can you tell me how you have tried to resolve these?
- What resources (equipment / software / social network / training) would you need to overcome these difficulties?
- Did you change the activity (nature of, timings of)?
- What else about either your own role, and or similar roles in informal contexts more generally would you like to share with me?
- Do you have any concerns about what you have shared with me today?
- Do you have any questions to me?