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The Possibilities of Use of Robotics in Finnish Early Childhood Education – Benefits and Challenges

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Robotit ovat muodostumassa osaksi jokapäiväistä elämäämme. Robotiikan hyödyntämistä opettamisen välineenä on tutkittu, mutta lisätutkimukselle on tarvetta, varsinkin kun puhutaan varhaiskasvatuksesta. Suurin osa tutkimuksista on keskittynyt robotiikan mahdollisuuksiin peruskoulu- ja ylemmän asteen koulutuksen saralla.

Toiminnallisen opinnäytetyön tarkoituksena oli luoda suomalaiselle päiväkodille tietopaketti, jossa esitellään mahdollisuuksia integroida robotiikka suomalaiseen varhaiskasvatukseen ja välineitä hyödyntää sitä, käyttäen pohjana kirjallisuuskatsausta, jonka avulla saatiin luotua yleiskuva aiheesta olemassaolevien tutkimusten perusteella.

Aineistonhakuprosessissa hyödynnettiin useita kansainvälisiä tietokantoja. Aineisto koostui useammasta erilaisesta lähteestä, erilaisista artikkeleista ja julkaisuista. Suomen varhaiskasvatussunnitelma ja varhaiskasvatuslaki sekä ammattikirjallisuus loivat pohjan, johon tutkimuksia peilattiin.

Kirjallisuustutkimuksen tulokset osoittivat, että robotit tarjoavat pedagogisia mahdollisuuksia, jotka parantavat oppimista varhaiskasvatuksen tasolla. Sosiaalista robottia hyödyntämällä lasten suoritukset paranivat mm. geometrisen ajattelun ja metakognitiivisten taitojen saralla ja vuorovaikutus robotin kanssa oli lähinnä positiivista. Opettavat robotit voivat olla kelvollisia vaalimaan tarpeellisia elämäntaitoja, kuten kognitiivista ja persoonallista kehitystä. Suurimpana haasteena pidettiin varhaiskasvatuksen opettajien vähäistä tietämystä aiheesta, joka tuli ilmi myös tietopaketin esittelyn myötä. Moni opettaja vierasti ajatusta robotiikan käytöstä ja suurimmaksi haasteeksi nousi riittävä tietämys aiheesta ja osaaminen. Osa opettajista olisi valmis hyödyntämään robotiikkaa, jos heillä olisi tarvittava koulutus sen käyttöön.

Voidaan päätellä, että robotit voivat edistää oppimista esimerkiksi sosiaalisen ja emotionaalisen kehityksen, motoriikan ja fyysisen kehityksen, kognitiivisten kykyjen kehityksen sekä kielen ja viestinnän saralla. Robotiikka tuo mukanaan paljon eri mahdollisuuksia opetuksen saralla, mutta robotiikan oikeanlainen hyödyntäminen edellyttää opettajilta ammattitaitoa.

Avainsanat	varhaiskasvatus, STEM, sosiaalinen robotti, KindSAR, NAO, humanoidi, lastentarha

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Robots are slowly becoming a part of our everyday lives. Some research has been conducted on the use of robotics in education, but there is a need for further research, especially in early childhood education (ECE). Most researchers have focused on the possibilities of using robotics in education at the elementary or high school level, but little research has been conducted on utilizing robotics in ECE, at preschool stage.

The purpose of the functional thesis was to create an information package for a playschool in Finland that introduced the possibilities of integrating robotics into the curriculum and tools to utilize robotics. A literature review was used as the base of the information package to form a general understanding based on existing research and articles on the topic.

The data search was carried out by using international online databases. The literature consisted of a variety of materials such as scientific journals and articles. The National Core Curriculum for Early Childhood Education and Care, The Act on Early Childhood Education and Care as well as professional literature were used as theoretical framework for the study.

Findings of the literature review indicate that the use of robots can provide pedagogical opportunities that can enhance learning in ECE. With the help of a social robot, children's performance in areas such as geometric thinking and metacognitive tasks improved, and interaction with the robot was mainly positive. Educational robots may be suitable in fostering essential life skills like cognitive and personal development. The main challenge was teachers' lack of knowledge in integration and operation of the robots, which also came up during the presentation of the information package. Most teachers disliked the idea of using robotics and the biggest challenge was overall lack of competence and knowledge.

One can conclude that robots can promote learning in areas such as social and emotional development, motor and physical development as well as language and communication and perceptual-cognitive skills. It is evident that the right kind of utilization requires teacher competence.

Keywords	early childhood education, STEM, educational robotics, social assistive robot, KindSAR, NAO, humanoid, preschool

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1 Introduction

Robots are slowly becoming a part of our everyday lives and already in 2008, the number of service robots outnumbered industrial robots (IFR Statistical Department 2008). Research has been done about the use of robotics in education, but most researchers have focused on the possibilities and outcomes of using robotics in education at the elementary or high school level, but little research has been done about utilizing robotics in early childhood education, the kindergarten stage. The applicability of robots in early childhood education is still somewhat a “mystery”.

Many, especially those who don’t know too much about this kind of technology, are presumably quite reserved when robots and ECE are mentioned in the same sentence. People voice concerns about technology and robots taking over jobs, especially in the field of healthcare, for example elderly care. However, robots will never be able to fully replace human workers, especially in the field of healthcare, since it demands some sort of emotional intelligence and that is what robots lack: empathy skills. We must keep in mind that when computer games were first introduced into classroom, it was the initial assumption that computers could replace teachers. It soon became obvious, however, that the use of computers was not sufficient (Fridin, M., 2013).

We must consider the developmental objectives in ECE (Early Childhood Education) to see how we could benefit of the use of robotics and can it be integrated to the curriculum. I will start by presenting the legal framework and standards of ECE in Finland and explaining the objectives of Finnish early childhood education. I will look at the possibilities of utilizing robotics in ECE considering those premises.

Based on previous research articles and studies I focused on 3 different types of robotics and programming tools including:

1. KindSAR (Kindergarten Social Assistive Robot) - a humanoid robot
2. KIWI and KIBO robotics kit
3. LEGO WeDO set programmed with CHERP (Creative Hybrid Environment for Robotic Programming)

KindSAR is a humanoid robot. The most famous humanoid robot in the world is probably NAO, the first robot created by SoftBank Robotics, also used as an assistant by companies and healthcare centers (SoftBank Robotics, 2022). NAO was also used in the studies included in the literature review. KIWI, which later evolved to KIBO, is a robotics kit that teaches both engineering and programming (Sullivan, A. & Bers, M.U., 2018). LEGO WeDO is a set of software that has been programmed using CHERP. I will explain the operating models in more detail in chapter 5.

2 Early Childhood Education and Care

To understand how the use of robotics has been promoting developmental objectives in early childhood education and how to apply it, we must understand the aims and the meaning of early childhood education. The unique features of the Finnish education system, including the intrinsic value it places on childhood and play, its “whole child”- centred approach to ECEC, and the trust it places in teachers’ and institutions’ self-accountability continue to attract international interest. In Finland, the governments’ responsibility to provide education is written into the Finnish Constitution, ensuring that all families have access ECEC services. Finnish society and policies rest on a Nordic welfare model, aiming to provide high-quality education and care for children and their families on fair and equal grounds (Kumpulainen, K. & Sefton-Green, J., 2020).

The Finnish National Agency for Education has issued a national regulation, the National Core Curriculum for Early Childhood Education and Care, to be used as a basis for local curricula for ECEC (early childhood education and care). Since 1 August 2017, it has been regulated by law, that any service provider or municipality must use this curriculum as the basis for individual ECEC plans. The formulation is directed by the Act on Early Childhood Education and Care (OPH 2019). ECEC service providers must also meet Finnish legal requirements adhering quality measures, such as the National Core Curriculum, adult-child ratios, professional qualifications and structures considering staff (Kumpulainen, K. & Sefton-Green, J., 2020). The municipality and Regional State Administrative Agencies (AVI) are responsible for overseeing provision of all ECEC programs (Kumpulainen, 2018).

2.1 National Core Curriculum for Early Childhood Education and Care

The National Core Curriculum for ECEC contains instructions for developing local curricula while promoting implementation of high-quality and equal early childhood education in Finland (OPH 2019). It has an emphasis on pedagogy, and it specifies key objectives and contents of ECEC. The local curricula should be prepared in cooperation with local officials and any local features and plans must be considered (National Core Curriculum for Early Childhood Education and Care, 2018, p.8-10). All obligations of any organisation are based on the Act on Early Childhood Education and Care, for example, education must be provided in the child's mother tongue or sign language. Best interest of the child is primary, and a child's opinion must always be considered (National Core Curriculum for Early Childhood Education and Care, 2018, p.16-17).

2.1.1 Individual ECEC Plan

For each child in Finland, an individual ECEC plan is prepared, consisting of pedagogical activities and individual objectives and measures for supporting individual development, learning and well-being. It includes all information about the child, including the child's skills, interests and personal needs, if there are any, for example if special support is needed, a medical care plan is prepared and included in the plan. The plan is prepared with the guardians and the child, as well as other personnel and experts and it should be revised at least once a year (National Core Curriculum for Early Childhood Education and Care, 2018, p.10-12). Although the primary focus of parental engagement is supporting individual child's development, parents are also able to contribute to the development of ECEC in the local context. Both parents and children have the right to participate in planning, execution and evaluation of ECEC. Children's views are considered (Kumpulainen, K. & Sefton-Green, J., 2020). Although there is no performance requirement, teachers are required to observe and document each child's learning taking into account general objectives established by ECEC curriculum as well as individual objectives (Kumpulainen, K. & Sefton-Green, J., 2020).

2.1.2 Pedagogical Emphasis

Pedagogy is underlined in all activity in early childhood education. Pedagogical expertise is required to understand how to promote children's learning and well-being as well as transversal competence (National Core Curriculum for Early Childhood Education and

Care, 2018). According to the National Core Curriculum for ECEC, the precondition for high-quality pedagogical activities is systematic documentation, evaluation and development. A framework for pedagogical activity can be found in the National Core Curriculum for ECEC (Figure 1).

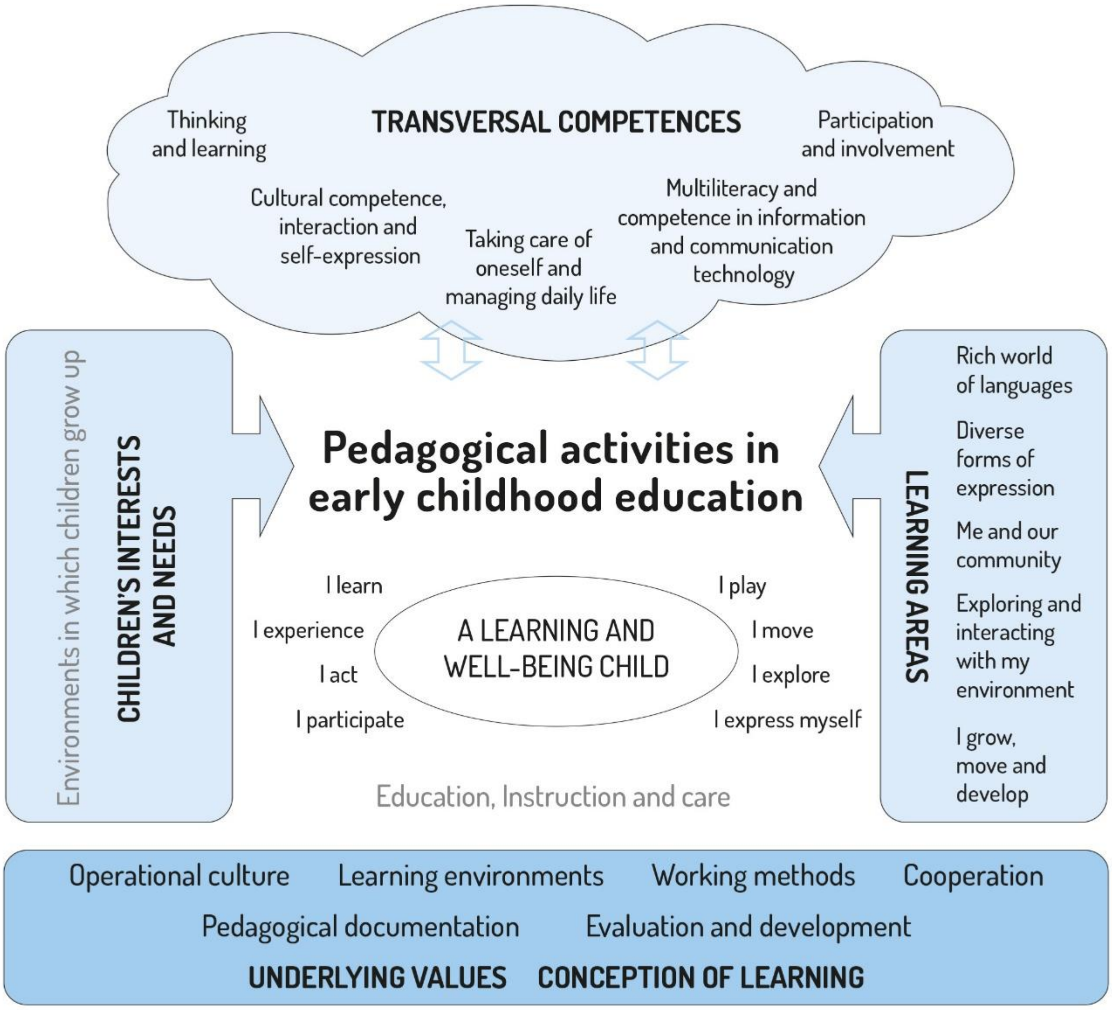

Figure 1. The framework for pedagogical activity in early childhood education and care (National Core Curriculum for Early Childhood Education and Care, 2018, p.40).

2.2 Transveral competence

The objectives of transversal competences guide the planning of the activities as well as the objectives specified by the local curricula, considering the children's individual plans and the form and characteristics of each service provider (National Core Curriculum for Early Childhood Education and Care, 2018,p.41). Also, a child's personal interests and needs together with different learning areas described in the National Core Curriculum for ECEC, should be used as basis for planning different pedagogical activities, which should always promote the development and learning of children.

According to the Finnish National Agency for Education (2022), ECEC lays the foundation and builds children's transversal competences, which are explained below.

1. Thinking and learning

Thinking and learning throughout life requires courage, enthusiasm and openness to new things, all of which early childhood educators need to promote and encourage with (Finnish National Agency for Education, 2022).

2. Cultural competence, interaction and self-expression

Cultural competence, interaction and self-expression are important skills in the diversifying world. Early childhood education creates a foundation for respecting other people and learning interaction skills (Finnish National Agency for Education, 2022).

3. Learning to take care of oneself

Learning to take care of oneself and to manage daily life is essential. With ECEC activities children learn to take care of their own wellbeing and the wellbeing of others whilst the principles of a sustainable way of living are also implemented (Finnish National Agency for Education, 2022).

4. Multiliteracy and ICT (Information and communication technology) competence

Multiliteracy and ICT (Information and communication technology) competence play an increasing part in children's life. Practising ways to act in different digital environments is the task of ECEC (Finnish National Agency for Education, 2022).

5. Participation and involvement skills

Participation and involvement skills and the motivation to learn new things strengthen when children can themselves have a say in what is done and how. It is important that

ECEC provides children with the opportunity to participate and practice their own possibilities to influence (Finnish National Agency for Education, 2022).

2.3 Learning Areas

The National Core Curriculum describes five different learning areas that should be used as the basis for planning pedagogical activities:

1. Rich world of language
2. Diverse forms of expression
3. Me and our community
4. Exploring and interacting with my environment
5. I grow, move and develop

Kumpulainen, K. & Sefon-Green, J. (2020) point out that “Each of these areas is framed by the concept of transversal competence – knowledge, skills, values, attitudes, and will – that support personal growth, lifelong learning, working life, and civic activity in the 21st century.”

2.3.1 Rich world of language

The task of ECEC is to develop children’s linguistic skills and capacity as well as their linguistic identities (National Core Curriculum for Early Childhood Education and Care, 2018, p.44). Language is a very important tool, because it provides the tools for interaction and self-expression, as well as skills for acquiring knowledge through reading. According to the National Core Curriculum for ECEC, linguistic identities develop as children are provided with guidance and support in the main areas of linguistic skills and capacity (Figure 2).

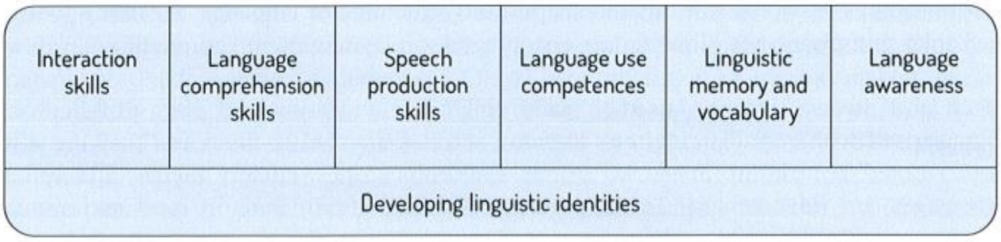

Figure 2. The main areas of children's linguistic development in early childhood education and care.

Children diversify their linguistic expression as their linguistic memory and vocabulary expand. The development of linguistic memory is supported by, for example, the use of nursery rhymes and singing games. Verbalising activities in a consistent manner, naming things and using illustrative words promote the development of children's linguistic memory and vocabulary, which supports their language comprehension skills. Discussions, reading and telling stories provide opportunities for considering the meanings of words and texts. Providing children with the opportunity to explain and speak in turns strengthens their language use skills. For the development of interactive skills and speech production skills, children's experiences of being heard and getting responses to their initiatives are important as well as encouraging the children to communicate (National Core Curriculum for Early Childhood Education and Care, 2018, p.44-46).

There are numerous ways in which robotics can be used to promote children's language skills. In a study done with the NAO humanoid robot, the robot taught children new concepts, made children name things and also practiced rhymes with the children. Through repetition of the new words and concepts, children's linguistic memory and vocabulary expands which promotes self-expression and literacy skills. Not to mention, that the NAO robot comments on what children say and gives feedback, thus the children have the experience of being heard and getting a response (Fridin, M., 2013). NAO has been shown to have a positive impact on child-robot interaction (Fridin & Yaakobi, 2011). Experiments using a humanoid robot have showed positive interaction levels suggesting that children enjoyed playing and interacting with the robot (Keren, G. & Fridin, M., 2014, Fridin, M.,2013) contributing that utilizing a robot made the learning process more significant. A good demonstration is that children's performances were strongly correlated with their interaction levels in one of the experiments (Fridin, M., 2013). One could conclude that learning with a robot might increase a child’s motivation to learn and promotes areas of transversal competences.

2.3.2 Diverse forms of expression

According to the National Core Curriculum for Early Childhood Education and Care (2018, p. 46), another task of ECEC is to support the development of children’s musical, visual, verbal and physical expression in a goal-oriented manner. Visual expression includes practices of visual thinking, observation and interpretation of images by paying attention to colours, shapes, materials and possible emotions rising from an image (National Core Curriculum for Early Childhood Education and Care, 2018, p.47).

Coding is becoming as fundamental to culture as literacy was before and the world nowadays is increasingly structured by computers and most things are in digital form. Teaching coding to children gives them a new set of tools for self-expression and digital competence providing possibilities for participation in the 21st century (KinderLab Robotics, 2018). Robotics can promote visual memory, language skills and understanding of mathematical concepts like size, shape and numbers.

In one study children were asked to bring a book to life with KIBO by programming the life cycles of the characters of the book, which required remembering how the story goes and in which order everything happened. This gives children the opportunity to decorate KIBO in a suitable manner and to act as storytellers whilst planning and programming KIBO to act accordingly to their ideas. This promotes children’s visual thinking and presenting the stories gives them a chance to practice their verbal skills and expression as well as their engagement in teamwork and collaboration while programming the robot together in a group (Elkin, M., et. al., 2018).

In another study children were asked to build an animal with a Lego WeDO kit and to program it to act accordingly to its character using three core programming concepts: sequencing, repeat loops and programming with a meaningful goal in mind (creative programming). Lastly the children were told to choose a goal for their robot and build a program to execute it (Strawhacker, A. & Bers, M.U., 2014). This gives the children the ability to express themselves and their ideas in numerous ways using their imagination whilst also promoting their cognitive skills.

2.3.3 Me and our community

According to the National Core Curriculum of ECEC (2018, p.48-49), children's capabilities of understanding diversity should be promoted, through practice of ethical thinking (telling right from wrong, justice), worldviews (religion, traditions, respect of other views, awareness), the past, the present and the future of the local community (to promote interest in history and building a better future) as well as the media (self-awareness, criticism, responsible use of media).

Dances from Around the World is a KIBO robotics and programming curriculum designed to engage children with STEAM (Science, Technology, Engineering, Arts, Mathematics) content through an integration of music, dance, and culture using engineering and programming tools. In the final project of the curriculum, students work in pairs or small groups to design, build, and program a cultural dance from around the world (Sullivan, A. & Bers, M., 2017). This can be a great way to learn about culture, traditions, history and community for example and children get to practice all areas of STEAM without any screen-time. The kit encourages creativity and artistic design, since children can personalize robotic creations with arts, crafts, and recyclable materials. In the Dances from Around the World curriculum the children decorated robot to present different ethnicities (Figure 3), thus highlighting the use of creativity and arts.

Figure 3. Robots were decorated to represent different ethnicities in Singapore (Sullivan, A. & Bers, M., 2017)

In general, using the KIBO robotics kit in groups promotes great social skills and collaboration skills, which both strengthen understanding of diversity and respect of others' views. While programming and brainstorming together the children act as a team and are involved in social interaction (Elkin, M., et. al., 2018).

2.3.4 Exploring and interacting with my environment

Children should develop a capacity to observe, analyse and understand their surroundings, which help children understand causal relationships. On top of promoting mathematical thinking, ECEC includes environmental education, which helps develop responsibility for nature (sustainable way of living) and understanding natural phenomena, and technology education, which helps children understand that technology is an outcome of human activity (National Core Curriculum for ECEC, 2018, p.49-50).

Anything man-made that has a useful purpose can be considered technology (Turja, 2017). Developing children's knowledge of the human-made world is needed for children to understand the environment they live in (Sullivan, A. & Bers, M., 2015). Through programming children learn concepts of sequencing, engineering design, logical order and cause and effect relationships. Whilst programming KIBO, children are involved in an engineer design process. Early childhood is the ideal time to begin teaching engineering concepts since children are beginning to make sense of the world and are interested in their surroundings, eager to explore and get answers to big questions (Elkin, M., et. al., 2018). KinderLab Robotics have a very similar picture of the engineering design process as the DevTech Research Group at Tufts University has created (KinderLab Robotics, 2017) which shows 6 steps (Figure 4) of the process.

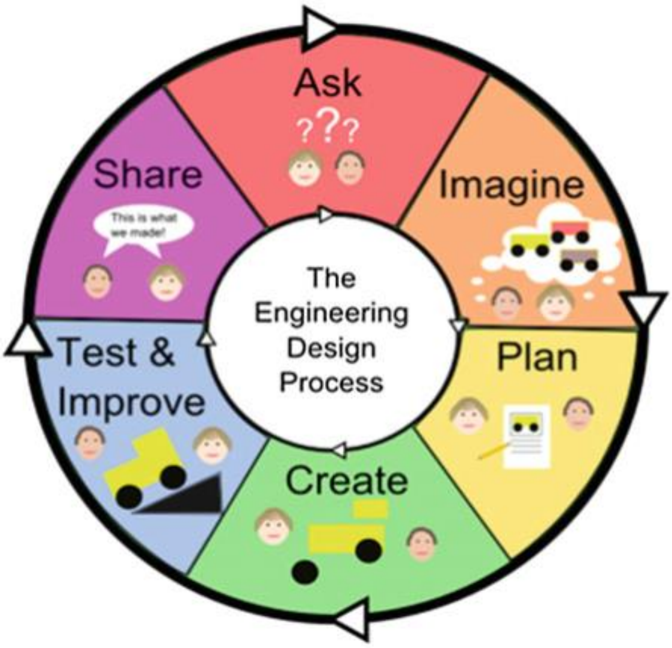

Figure 4. Engineering design process by DevTech Research Group at Tufts University (Elkin, M., et. al., 2018)

This engineering process in in-line with the process engineers use when designing, for example an engineering process by Hynes (2012) that has 8 steps: (1) identify need or problem, (2) research need or problem, (3) develop possible solutions, (4) select best possible solution, (5) construct a prototype, (6) test and evaluate solution, (7) communicate the solution, and (8) redesign. While children are not designing to meet a specific need or problem, steps 1 and 2 (in Hynes' example) are in line with the first step "Ask". The second step ("Imagine") is about developing possible solutions and "Plan" is selecting the best solution. Hynes' step 5 (construct a prototype) is in line with step 4 ("Create") in the children's cycle. Step 5 ("Test & Improve") is basically the same as Hynes' step 6 (test and evaluate solution) and step 8 (redesign) put together. The final step "Share" goes in hand with Hynes' step 7 (communicate the solution). However, the children's steps aren't actually numbered, and KinderLab Robotics (2017) encourages to start at any step and move back and forth or around in a cycle.

The step of testing and improving is crucial because it forces children to experience to failure and move onward, which is necessary for learning (Elkin, M., et. al., 2018). By developing a "growth mind-set" attitude children are improving their skills for facing challenging situations. Growth mind-set refers to the belief that one's abilities can be developed with dedication and hard work (Dweck, 2006). Dweck (2016) explained that: "Individuals who believe their talents can be developed (through hard work, good strategies, and input from others) have a growth mindset. They tend to achieve more than those with a more fixed mindset (those who believe their talents are innate gifts)".

2.3.5 I grow, move and develop

The fifth learning area, according to the National Core Curriculum for ECEC (2018, p.51), includes objectives related to physical activity, food education, health and safety, aiming at providing the children an understanding of a way of living that values health and well-being (exercise, rest, safe relationships) and regular physical activity. Body awareness and knowledge, as well as motor skills, are developed, through practice of physical activity (National Core Curriculum for ECEC, 2018, p.51-52).

2.4 Learning Through Play

Play is significant for learning. Children don't personally see play as a vehicle for learning, it rather motivates them and brings joy while allowing the children to learn skills and acquire knowledge (National Core Curriculum for ECEC, 2018, p.42-43).

Children are active agents while they play: they structure and explore the surrounding world, make observations, create social relations, construct ideas of themselves and form meanings based on their experiences. The use of imagination in play enables children to experiment with different roles and ideas, since play makes it safe to experiment, try and fail. Children learn the rules of the community through play, which additionally increases sense of community, strengthening a positive emotional atmosphere (National Core Curriculum for ECEC, 2018, p.42-43).

2.5 Technological culture

Anything man-made that has a useful purpose can be considered technology (Turja, 2017). For example, a cheese cutter is technology just as well as a tv. However, Introna (2002) states that: "Technology is never mere artifact. Technology 'is' what it is when it functions in the world as 'possibilities for' doing something. If we want to understand technology, we must understand the world it makes possible." Heidegger urges us to understand technology as a phenomenon which's meaning is the way it functions in a world of everyday going on. Technology is the possibilities it reveals to us everyday – not a substance, but rather a temporal event (Heidegger, M:, 1977).

The Department of Teacher Education of University of Turku, Faculty of Educational Sciences of University of Helsinki, University of Tampere and Innokas Network collaborated on a 3-year long program called InnoPlay through years 2018-2021. The purpose of InnoPlay is to give teachers tools for their work and support them when it comes to increasing their technological knowledge and competence in teaching STEAM related subjects. The program aims to develop pedagogical methods for integrative STEAM education, which integrate craft, environmental and technology (CDT) education and mathematics in ways that motivate younger learners; play, exploring and self expression (InnoPlay, 2022).

2.6 Digital Skills

Technology education is a new element in the foundations of the early childhood education plan (OPH, 2018). Information and communication technology (ICT) have been renewed in the National Core Curriculum of ECE, according to feedback collected during the years 2019-2021. They were changed to correspond to the modern concept of digital skills. The renewed local ECE plans will be introduced in all day care centers on 1.8.2022 (OPH, 2022).

In modern times, digital competence is needed for human interaction, learning and being able to function in the society and it is the duty of ECE to support children's understanding of the digital work in co-operation with the children's parents (OPH, 2022). It is as important to teach children coding and technology as it was to teach children to write in earlier centuries, because today digital competence is very important for self-expression and participation (KinderLab Robotics, 2018). Providing children with opportunities to practice, experiment and produce content using digital tools together promotes children's creative thinking, collaboration and multiliteracy skills. Teachers in ECE must guide children to a responsible and safe use of digital environments (OPH, 2022).

2.7 Multiliteracy

Multiliteracy is a component of transversal competence in the Finnish education curriculum and is considered as an essential competence to enable children to interpret the surrounding world, perceive cultural diversity and build their own identities (Multiliteracy as one of the foundations of the Finnish basic curriculum, 2017). In Finnish education, multiliteracy is not taught as a subject of its own, but as part of other curriculum contents that needs to be incorporated across the curriculum (Kumpulainen, K. & Sefton-Green, J., 2020). Early childhood education aims at supporting the development of interaction and social participation skills, which both benefit from competence in multiliteracy (OPH, 2022).

Multiliteracy is the skill of acquiring, combining, modifying, producing, presenting and evaluating information in different forms, in different environments and situations, and using different tools (Multiliteracy as one of the foundations of the Finnish basic curriculum, 2017). It is about how one interprets and produces different kinds of messages, the capability to evaluate information. Multiliteracy is coexistence. Multiliterate people take an open attitude toward different people and cultures (Kumpulainen, K. et al., 2018). Kristiina Kumpulainen et. al. (2018, p.4) even states that: “People who are not multi-literate have a poor understanding of their physical and cultural environments. Their own thinking and understanding are easily subjugated by rigid beliefs and their worldview remains limited and narrow. In short, multiliteracy means an opportunity for comprehensive inclusion and responsible participation.” This underlines the importance of multiliteracy in the modern world. However, in Finland it is still hard to promote multiliteracies in education, because of varying definitions that make it hard to grasp the exact meaning of the concept (Kumpulainen, K. & Sefton-Green, J., 2020).

In early childhood education things and objects are named and numerous concepts are learned. Children are encouraged to explore, produce and present in numerous settings (OPH, 2022). Among other competences, multiliteracy has been renewed in the National Core Curriculum for ECE (OPH, 2022). Strengthening digital literacy and multiliteracy promotes children's educational equality (OPH, 2022). However, research has shown that children’s opportunities to learn from digital technologies and media at home vary depending on how their families interact with technology and media or if the parents frame the use of media. Parents’ background, digital skills and attitudes towards technology also impacts children’s engagement with multiliteracies (Kumpulainen, K. & Sefton-Green, J., 2020).

Finland does not have a particular history of work in multiliteracies, a term and concept deriving more from an Anglo tradition in Canada, the United States, UK and Australia (Kumpulainen, K. & Sefton-Green, J., 2020). The Ministry of Education and Culture launched a nationwide development programme called the Joy of Learning Multiliteracies (MOI) to promote multiliteracy by developing not only different actions for children’s learning, but also the expertise of personnel. The Joy of Learning Multiliteracies (MOI) development programme is intended for personnel working in ECE, pre-school and primary education (Kumpulainen, K. et al., 2018).

As a new concept in Finnish curriculum – introduced through the new National Core Curriculum of ECEC as a transversal competence – the concept might still be somewhat unclear for teachers. The MOI program developed Whisper of the Spirit cards to promote children’s multiliteracies, which was found useful and inspiring by four Finnish teachers, who took part on a study exploring how these teachers used the pedagogical material (Kumpulainen, K. & Sefton-Green, J., 2020). Kumpulainen et al. (2018) explains that

”The educational aim of the activity cards is for children to take an interest in Finnish nature and ancient beliefs from a variety of perspectives. The tasks encourage children to observe, reflect, innovate and experiment. The material package is versatile, and it can be used on various digital devices.” Since STEAM education, ICT and multiliteracies are becoming a distinct part of ECEC, teachers will need these kinds of new materials and ideas to help them innovate their teaching process. These new concepts and pedagogies should be embedded in their teaching materials. We must keep in mind that early childhood educators are working with the first generation of children who have had smart technologies in the world since they were born (Kervin, L. & Comber, B. 2020).

The components of multiliteracy are in line with ecological literacy (eco-literacy), which refers to “the ability to understand the basic principles of ecology – the processes by which the Earth’s ecosystems sustain the web life” (Stone, 2017) and underlines going beyond basic skills towards cultivating human capacity to observe nature and to relate to knowledge with inside and quality of thought (Orr, 1992). Multiliteracies pedagogy combined with the principles of eco-literacy offer an educational opportunity for the promotion of young children’s learning about sustainability-oriented knowledge, skills and empathy for the natural world (Kumpulainen, K. & Sefton-Green, J., 2020). In Finland, the National Core Curricula mandates that formal education should develop children’s eco-social knowledge and ability, understanding of human dependence on ecosystems and nurture their knowledge and appreciation of their environment for a sustainable future. Teachers are required to promote children’s outdoor learning opportunities (Kumpulainen, K. & Sefton-Green, J., 2020).

3 Objectives

The purpose of the thesis was to analyse what kind of results have been achieved by utilizing robotics in ECE and to look at possible benefits robotics could offer to early childhood education in Finland based on these results. The objective was to provide an information package (considering these results) to be presented at a playschool in Helsinki – Pilke Playschool Lehtisaari - to help them learn about the possibilities of using robotics. Possible challenges that were also examined and discussed. Permission to use the information acquired from the discussion in my thesis was granted.

4 Implementation

4.1 Literature review

A literature review was conducted to form a general understanding of utilizing robotics based on of existing research and articles on the topic. A literature review can broadly be described as a more or less systematic way of collecting and synthesizing previous research (Baumeister, R. F. & Leary, M. R.,1997). By integrating findings and perspectives from many empirical findings, a literature review can address research questions with a power that no single study has (Snyder, H.,2019,p.333). It can inspire research ideas by identifying gaps or inconsistencies in a body of knowledge, thus helping the researcher to determine or define research questions or hypotheses (Cronin, P. et al., 2008).

The literature used consisted of a variety of materials, diverse in content, such as scientific journals and articles. The National Core Curriculum for Early Childhood Education and Care, The Act on Early Childhood Education and Care as well as professional literature were used as theoretical framework for the study. An information package was then put together considering the findings of the literature review and discovering the benefits it can offer to ECE in Finland by looking at the framework of Finnish ECEC.

4.2 Data Search Process

The data search was carried out by using international online databases such as DOAJ, Taylor & Francis and ProQuest. The search was conducted by using search words “Robotics”, “Early Childhood”, “STEM”, “NAO” and authors’ names, when using Google Scholar. With ProQuest the search was filtered to “Education/Teaching methods & materials / Science & Technology.”

Depending on the amount of results the titles were read through, leaving out titles that undeniably didn’t qualify for this research. The rest were skimmed through to see which ones covered the inclusion criteria. Finally, after reading the data thoroughly, the final decision was made in the inclusion process. Many of the articles and journals were excluded, because they only remotely matched the criteria or were published before 2010.

Included data						
Author	**Publication Date**	**Title**	**Research**	**Tools**	**Results**	**Trust-worthiness**
Guy Keren, Marina Fridin	Elsevier Ltd. 2014	Kindergar-ten Social As-sistive Ro-bot (Kind-SAR) for children's geometric thinking and metacogni-tive develop-ment in pre-school edu-cation: A pi-lot study	To show how Kinder-garten Social Assistive Robot-ics (KindSAR) technol-ogy could assist kinder-garten staff in teaching preschool children geo-metrical thinking and development of chil-dren's metacognition in one set games.	A small hu-manoid robot Nao.	A robot can assist the teacher in promot-ing geometric think-ing learning through game-like educa-tional activity. Data revealed significant improvement in the children's metacog-nitive abilities in the second session of the experiment compared to the first.	Yes.
Marina Fridin	Elsevier Ltd. 2014	Storytelling by a kindergarten social assis-tive robot: A tool for con-structive learning in preschool education	How KindSAR can be used to engage preschool chil-dren in constructive learning. In this study, storytelling was used as a paradigm of a con-structive educational activity.	A small hu-manoid robot Nao. Video and audio data were col-lected dur-ing the ex-periment and ana-lyzed.	Our results show that the children en-joyed interacting with the robot and accepted its author-ity. This study demonstrates the feasibility and ex-pected benefits of incorporating Kind-SAR in preschool education.	Yes.
Amanda Strawhacker, Marina U. Bers	Springer Sci-ence+Busi-ness Media Dordrecht, 2014	''I want my robot to look for food'': Comparing Kinder-gartner's program-ming com-prehension using tangible, graphic, and hybrid user interfaces	This study aims to ex-plore how successfully young chil-dren master founda-tional programming concepts based on the robotics user interface (tangible, graphical, hy-brid) taught in their cur-riculum. Thirty-five Kin-dergarten students par-ticipated in a 9-week ro-botics curriculum using the LEGO WeDo robot-ics construction kit and CHERP.	LEGO WeDo ro-botics con-struction kit and the Creative Hybrid En-vironment for Robotic Program-ming - CHERP.	The small sample size of all three classrooms makes it difficult to draw conclusions about the results. Alt-hough the results are inconclusive, this pilot study shows that for Kin-dergarten students, using a tangible programming lan-guage may be re-lated to enhanced comprehension of abstract concepts like repeat loops.	Yes.
Mollie Elkin, Amanda Sullivan and Marina Umaschi Bers	Springer Nature Sin-gapore Pte Ltd. 2018	Books, But-terflies, and 'Bots: Integrating Engineering and Robot-ics into Early Childhood Curricula	Describing how robotics can be used to learn foundational engineer-ing and computer sci-ence concepts. Pre-senting vignettes from three classrooms that embarked on an eight-week KIBO robotics curriculum. Educators were able to integrate robotics with traditional early childhood content such as literacy and science.	KIBO	Children were able to succesfully program their robots and present complex work by the end of the curricu-lum. Each group was able to articulate their rea-soning behind their pro-gramming.	Yes.

Included data						
Author	**Publication Date**	**Title**	**Research**	**Tools**	**Results**	**Trust-worthiness**
Amanda Sullivan, Marina U. Bers	Springer Science+ Business Media Dordrecht 2017	Dancing robots: integrating art, music, and robotics in Singapore's early childhood centers	This study looks at a sample of preschool children who completed a 7-week STEAM KIBO robotics curriculum in their classrooms called ''Dances from Around the World.'' Children's knowledge of programming concepts were assessed upon completion of the curriculum using the Solve-Its assessment. Data was collected on students' programming knowledge at the midpoint and endpoint of curriculum implementation.	KIBO	The Solve-Its were scored on a scale of 0–6 based on how close they were to the correct answer. On all tasks, students had a mean score of 5 or higher, out of 6 possible points (both mid-test and post-test). Results demonstrate a very high level of mastery on all concepts taught.	Yes/No. The results were collected by teachers instead of researchers which may indicate tht the results may not be 100% accurate.
Amanda Sullivan, Elizabeth R. Kazakoff and Marina U. Bers	Journal of Information Technology Education, 2013.	The Wheels on the Bot go Round and Round: Robotics Curriculum in Pre-Kindergarten	This paper qualitatively examines the implementation of an intensive weeklong robotics curriculum in three Pre-Kindergarten classrooms. The children used CHERP to program "Robot Recyclers" that they constructed using parts from LEGO® Education WeDo™ Robotics Construction Sets. The Robot Recyclers were designed to help carry, push, and/or sort recyclable materials found in the classroom.	CHERP	This study demonstrates that it is possible to teach Pre-Kindergarten children to program a robot with developmentally appropriate tools, and, in the process, children may not only learn about technology and engineering, but also practice foundational math, literacy, and arts concepts.	Yes.
Mollie Elkin, Amanda Sullivan & Marina Umaschi Bers	Computers in the Schools, 2016.	Programming with the KIBO Robotics Kit in Preschool Classrooms	Preschool students participated in a nine-hour introductory robotics and programming curriculum. Upon completion of the curriculum, students completed a KIBO programming task (called "Solve-It") to assess their programming knowledge.	KIBO	For all tasks on the Solve-It assessment, basic descriptive statistics were calculated. On average, the children in this study were highly successful at mastering basic programming concepts after completing the curriculum. Preschool children in the study, ages 3 to 5, were able to successfully master sequencing a syntactically correct program.	Yes.

Table1. Included Data.

The included data had to fit three simple criteria: the data was published between 2011 and 2021, the research presented addressed children of the ages 2-6 and the article was published by a reliable source. All articles that were published more than ten years ago were excluded. Additionally, articles that addressed the use or Robotics, but at an elementary school level or high school level were excluded. Needless to say, exclusion criteria also included articles published by an unknown or otherwise unreliable source.

Inclusion Criteria	Exclusion criteria
Published between 2011-2021	Published more than 10 years ago
Relevant to research questions	Not relevant enough
Addresses Early Childhood Education	Addressed higher Education
Trustworthiness/ Trusted source and publisher	Untrustworthy source/ publisher

Table 2. Inclusion and Exclusion of Data collection.

4.3 Critical Appraisal of Data

Critical appraisal is the process of carefully and systematically examining a research report to judge its trustworthiness, make sense of the results and assess the relevance of the findings in a particular context (Burls, A., 2014, p.1). When critically appraising research, it is important to first look for biases in the study; that is, whether the findings of the study might be due to the way in which the study was designed and carried out, rather than reflecting the truth (Burls, A., 2014, p.3). Every day we meet statements that try to influence our decisions and choices by claiming that research has demonstrated that something is useful or effective. Before we can believe such claims, we need to be sure that the study was not undertaken in a way such that it was likely to produce the results observed regardless of the truth (Burls, A., 2014, p.3).

5 Findings of the literature review

5.1 Included data

Finding suitable data was challenging, because a significant amount of research has been done about using robotics as a tool for teaching, but most research focuses on children at the elementary school level or older children. The use of robotics in a kinder-garten setting is at its starting point, but gladly, some research has already been done.

5.1.1 KindSAR (Humanoid Robot)

Socially assistive robotics (SAR) are defined as the intersection of AR (assistive robotics) and SIR (socially interactive robotics). SAR shares with assistive robotics the goal to provide assistance to human users, but it specifies that the assistance is through social interaction (Feil-Seifer & Mataric, 2005). Kindergarten Social Assistive Robotics (KindSAR) is a pre-school educational application of a class of robots known as Social Assistive Robotics (Feil-Seifer & Mataric, 2005).

Included in the data used is a pilot study that demonstrates how KindSAR can assist educational staff in the teaching of geometric thinking and in promoting the metacognitive development by engaging children in interactive play activities (Keren, G. & Fridin, M., 2014) in addition to a study that examines how KindSAR can be used to engage preschool children in constructive learning (Fridin, M., 2013). NAO, a small toy-like humanoid robot previously shown to have a positive impact on child-robot interaction (Fridin & Yaakobi, 2011) was used in both studies (Figure 5). NAO is a smart, non-threatening educational tool that speaks in a child-like voice, expresses emotions (through verbal and non-verbal cues) and uses proper vocabulary and grammar (Fridin, M., 2013). A third study using a humanoid robot was included in the data, which used a HOAP-2 humanoid robot (Meltzoff, A.N. et al., 2010) quite similar to a NAO, whilst they both have 25 degrees of freedom, allowing them to perform various motor functions (Meltzoff, A.N. et al., 2010, Fridin, M., 2013). The third study was however later removed, because of its suitability.

Figure 5. NAO[6] (Aldebaran & United Robotics Group, 2022)

5.1.1.1 *Kindergarten Social Assistive Robot (KindSAR) for children's geometric thinking and metacognitive development in preschool education: A pilot study (first study)*

The kindergarten staff participated in the design of the experimental procedure and approved its final implementation in the pilot study. Playing with a robot is an unusual experience, which is why there was a ''First Meeting'' procedure held first, during which the robot met the children, explained that its intention was to play with them, and played a short game of ''Simon Says'' with them. After the first meeting, the procedure of ''Four Seasons'' game, which comprised of two parts, took place. First the children must listen to the music of Vivaldi's Four Seasons and engage with images on the computer monitor that represented each of the year's seasons, while following the robot's body movements and dance with it to each of the four parts of Vivaldi's composition. Afterwards the monitor displays an image of the KindSAR . On the head and body of the pictured robot are four buttons, each marked by a picture of a season. The robot would then ask a child to press a button with a specific season image on its body and the child has to first locate the button marked by that season on the robot's image on the monitor and then press the corresponding button on the robot. In the second part, a child who has performed the task successfully must explain to a child who was not present during the procedure, what the object of this task is and how he/she performed it (Keren, G. &

Fridin, M., 2014). These two partis (the cognitive stage and metacognitive stage) are presented in Figure 6.

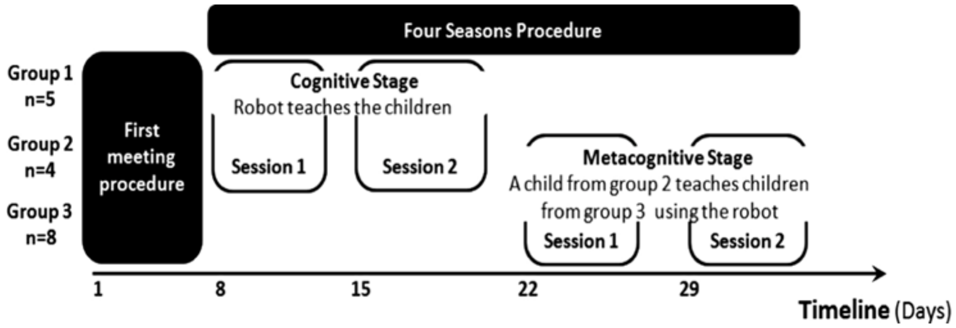

Figure 6.Scheme of the procedure protocol (Keren, G. & Fridin, M., 2014).

The robot starts the procedure by waking up, greeting the children and explaining the activity. It told the children to look at the monitor and focus on pictures while dancing and during the activity it would ask the children which season would come next, emphasizing the cyclicity in nature. The van Hiele theory of geometric thinking levels was applied in order to develop the children's geometric thinking (Keren, G. & Fridin, M., 2014).

5.1.1.2 Storytelling by a kindergarten social assistive robot: A tool for constructive learning in preschool education (second study)

The same first meeting procedure "Simon Says" was "used" in this study as well. "To explain its limitations and in keeping with the study's ethical requirement of preventing the children, as far as possible, from becoming emotionally attached to it, NAO emphasized its non-human character, by repeatedly stating that it is a robot and incapable of understanding everything" Fridin, M. (2013) explains.

A week later, NAO initiated a storytelling procedure (Figure 7), comprising of two storytelling sessions, one week apart. In both sessions, NAO entered the space, greeted the children and explained the activity. Two stories were selected ("Where is Pluto?" and "The Ugly Duckling") and additional technology was used (images illustrating scenes from the story) in the latter one, with strong emotional content. While telling the stories, expressing emotions both bodily and vocally, NAO taught the children new concepts, incorporated singing during the procedure and introduced motor games. NAO gave the children feedback and changed the colour of the light in its eyes, simulating a human-like shift of attention to different children, whilst constantly moving (Fridin, M., 2013).

Figure 7. Outline of the storytelling procedure (Fridin, M., 2013)

5.1.2 KIWI and KIBO Robotics Kit

KIBO robotics kit was developed by the DevTech Research Group at Tufts University and commercialized by KinderLab Robotics. It is a newly developed robotics kit that teaches both engineering and programming (Sullivan, A. & Bers, M.U., 2018). KIBO's predecessor was KIWI, which was developed because of the lack of developmentally appropriate robotics kits for young children. The KIWI prototype was developed by the DevTech Research Group at Tufts University, through funding from the National Science Foundation. KIWI involved hardware (the robot itself) and the software used to program KIWI called CHERP (Creative Hybrid Environment for Computer Programming). KIWI went through several design iterations and was tested in numerous public and private schools to inform the re-design of KIWI to make it enjoyable and appealing to children. (Sullivan, A. & Bers, M.U., 2016). Now it is called KIBO (Figure 8). KIBO's programming method is rooted in years of research identifying the most efficient ways to introduce coding in early childhood education (KinderLad Robotics, 2018).

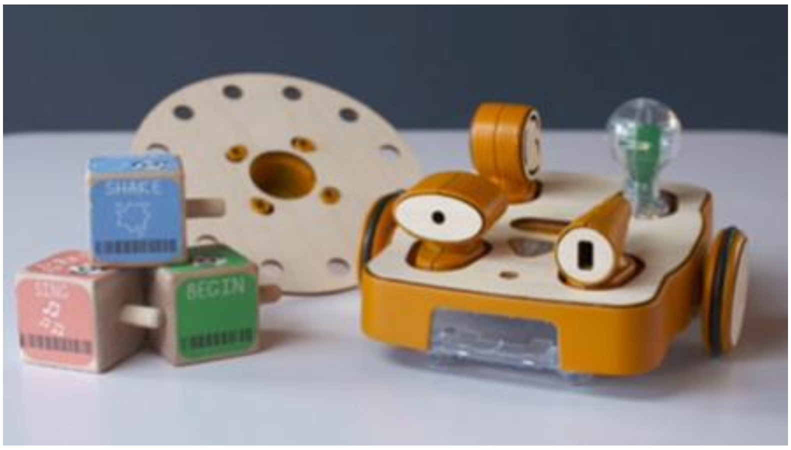

Figure 8. KIBO robotics kit (Elkin, M. et al., 2018)

KIBO's actions are programmed by putting together wooden blocks, no screen-time required, hence it is aligned with the American Academy of Pediatrics' (2003) recommendation that young children have a limited amount of screen time per day (Elkin, M. et al., 2016 & Sullivan, A. & Bers, M.U., 2018). More specifically, the kit contains easy-to-connect robotics materials including wheels, motors, light output, and a variety of sensors and as mentioned, it is programmed by using interlocking wooden programming blocks (Figure 9). These wooden blocks contain no embedded electronics or digital components, but each one has a unique barcode, which is scanned by a scanner embedded in the front of the KIBO robot and sent to the robot instantly (Elkin, M. et al., 2016).

Figure 9. KIBO wooden programming blocks (Elkin, M. et al., 2016)

KIBO has specific syntax to follow, every program must start with a Begin block and finish with an End block. Additionally, in order to create a functional repeat loop, one must use the Repeat block, a parameter (either a number or sensor), and the End Repeat block. In addition to teaching engineering and programming concepts, the KIBO robotics kit encourages creativity and artistic design in young users. The kit contains two art platforms that can be used to personalize robotic creations with arts and crafts (Elkin, M. et al., 2018). The KIBO robotic kit contains many blocks (Figure 10), but one can use the accordingly to the children's age, for example, only use the simple "commands" in the beginning and then learning about repeat loops and harder optional sequencing.

Figure 10. The KIBO robot and the blocks. (Elkin, M. et al., 2018).

KIBO is designed for young children ages 4 to 7 to learn foundational engineering and programming content, but a pilot study included in the data examined the hypothesis that it may be developmentally appropriate to use with children as young as 3 years old, by collecting data on children’s knowledge of programming concepts after completing a robotics curriculum (Elkin, M. et al., 2016). At age 3, most children can organize themselves to complete tasks that involve following two steps, such as putting away their lunchbox after snack time, but by the time children are leaving preschool and entering kindergarten around age 5, children can follow multi-step instructions and retell familiar stories in the correct sequence (Rhode Island Department of Education [RIDE], 2013). This is why, it is an interesting hypothesis to follow.

Another study examines a sample of preschool children’s mastery of foundational programming concepts after having completed a 7-week KIBO robotics curriculum called Dances from Around the World (Sullivan, A. & Bers, M.U., 2018). In the particular study, KIBO was implemented as part of Singapore’s Playmaker Programme, which is an initiative to introduce younger children to technology (Digital News Asia 2015).

A third article, where KIBO is utilized describes how robotics can be used in early childhood classrooms to learn foundational engineering and computer science concepts by presenting vignettes from three early childhood classrooms that embarked on an eight-week KIBO robotics curriculum (Elkin, M. et al., 2018). These vignettes highlight the very different approaches teachers took to introducing robotics to their students and how they utilized the engineering design process as a teaching tool that can be applied to most subject areas. The study also paid attention to how the teachers managed with the robotics kit and if they were able to integrate it to their curriculum (Elkin, M. et al., 2018).

5.1.2.1 Books, Butterflies, and ‘Bots: Integrating Engineering and Robotics into Early Childhood Curricula (first study)

The curricula were created collaboratively between three classroom teachers, the librarian, the art teacher, and researchers at the DevTech Research Group and Lesley University, leveraging each group’s expertise, all agreeing on three objectives. Firstly, the need to address engineering, robotics and programming concepts, secondly, the final project component needed to connect to a topic already being studied and lastly, a component of each class’ final project needed to include visual arts. The curricula were divided into 8 sessions. During the first 6 sessions, the children were familiarized with KIBO and engineering concepts and the last 2 sessions were devoted to working on the final projects. The sessions were taught by Tufts University researchers and supported by classroom teachers (Elkin, M. et al., 2016).

For each session, students learned a new concept and were then challenged to perform a specific engineering or programming task to make them practice the concept they were taught. At the end of each session, students had the opportunity to present what they created and had the chance to get feedback from their peers and to discuss what was easy and what was challenging, helping the teachers take knowledge of what concepts were understood (Elkin, M. et al., 2016).

Teachers hadn’t planned the final projects beforehand but wanted to see how students used the robot. They brainstormed idea and the refined ideas with the researchers. The process was the same in both classes. Firstly, the teachers reviewed the subject content, secondly students brainstormed ideas that could be brought to life with KIBO, then they recorded ideas in their journals and then they created those programs for their robot, tested the, and modified them. Lastly, they decorated the robots with arts, crafts and recycled materials before their final presentations of the projects. This brainstorming and creating the final project followed the steps of the engineering design process (Elkin, M. et al., 2016).

5.1.2.2 Dancing robots: integrating art, music, and robotics in Singapore's early childhood centers (second study)

This study uses a mixed-method design that includes data collected from a sample of preschool students and their teachers living in Singapore. It analyses quantitative data as well as qualitative data in order to present a full picture of a robotics experience. One goal was to allow teachers to gain confidence in adapting and teaching with KIBO in their own way (obviously correlated to meet the learning areas in ECE) instead of a strict plan to follow (Sullivan, A. & Bers, M.U., 2018).

Teachers from 5 different school took part in a 1-day training of KIBO robotics, while learning about the Dances from Around the World Curriculum, which is a KIBO robotics and programming curriculum that promotes an integration of technology and engineering concepts with an exploration of music and culture. teachers came up with their own adaptation of the curriculum and a calendar plan for their classes. Data was collected on students' knowledge at midpoint and end of the curriculum (Sullivan, A. & Bers, M.U., 2018).

Sullivan, A. & Bers, M.U. (2018) explain that "because the students in Singapore speak different languages and have different cultural backgrounds, the Dances from Around curriculum easily integrated into cultural appreciation and awareness units already typically taught in the preschool classes." Teachers introduced students to new programming concepts through weekly lessons, which each was connected to the theme of music, culture or dance, leading to a final project. Concepts from basic sequencing through conditional statements were covered. For the final project, students worked in pairs or groups to design, build and program a cultural dance from around the world and decorated their KIBO appropriately (Sullivan, A. & Bers, M.U., 2018).

5.1.2.3 Programming with the KIBO Robotics Kit in Preschool Classrooms (third study)

In this study, seven classrooms completed an introductory robotics curriculum taught by students from a variety of backgrounds from arts to engineering, but they all had worked with children before, and they all were from Tufts University. They had a training before the start of the intervention and midway through it in order to practice the curriculum and administering assessments. The children's regular preschool teachers were in the classroom to assist and to observe and learn from trained students in order to be able to implement their own robotics curriculum in the future. It was a 6-day curriculum where each day's lesson was divided into two parts, first part doing an activity with KIBO and the second part doing robotics and engineering related activities without involving KIBO. During robotics time, children were given a task to complete involving their robot. The second part had a group activity where children learned songs and listened to picture books being read aloud and after the group activity there was a "free-choice" time at the end where children could choose any activity related to KIBO (for example KIBO Bingo, KIBO Says or creating decorations for KIBO or drawing in their engineering design journals) (Elkin, M. et al., 2018).

Children had previously learned about different dances from around the world and on the final day, each class was given KIBO robot kit to build and program together, which in this case meant creating a dance program for their robot to perform and then during the non-robotics time the students decorated their robot and created a stage for it to dance on, while they presented their work in the end (Elkin, M. et al., 2018).

5.1.3 CHERP and LEGO WeDO

CHERP (Creative Hybrid Environment for Robotic Programming) is a programming language specifically designed to program a robot's behaviour, which is also developmentally appropriate for children (Sullivan et al., 2013). CHERP converts physical programs into digital instructions. Each wooden block in the language is imprinted with a circular symbol called "TopCode", which allow the position, orientation, size, shape, and type of each statement to be quickly determined from a digital image. A standard webcam can be connected to a desktop or laptop computer to take a picture of the program (Figure 11). A compiler converts the picture into digital code that is downloaded and transmitted to the WeDo™ robot through the LEGO® WeDo™ USB hub (Sullivan et al., 2013). The idea is similar to KIBO, whereas KIBO has its own scanner that scans the barcodes, which are similar to these "TopCodes" (Elkin, M. et al., 2016), enabling use without any wires or hubs.

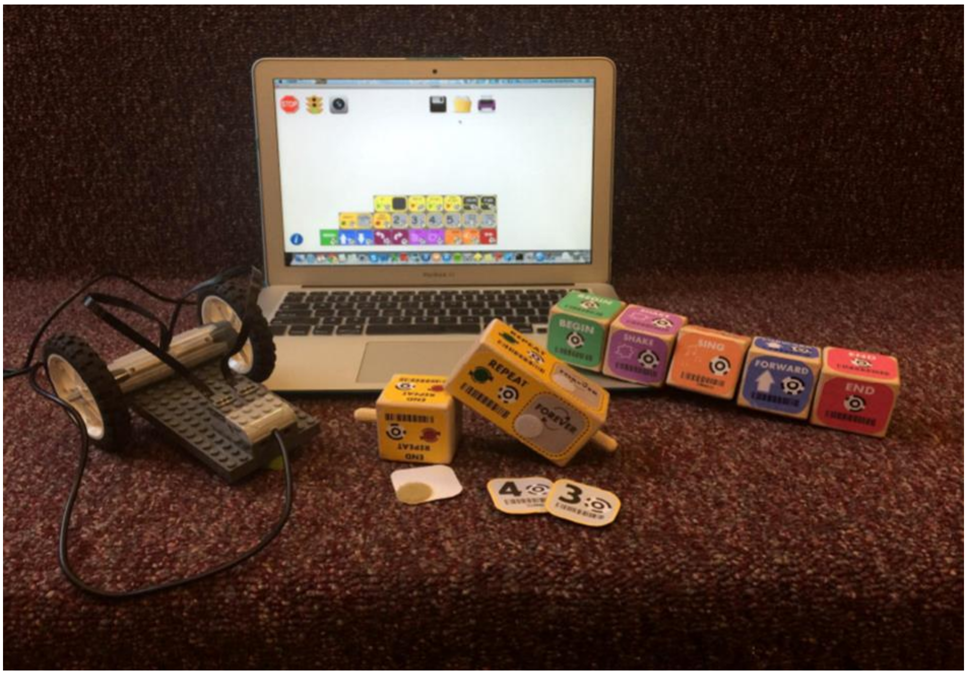

Figure 11. CHERP interfaces and LEGO WeDo robotic kit (Strawhacker, A. & Bers, M.U., 2015)

In two studies, children used the LEGO WeDo robotics construction kit and CHERP programming language. The other experiment was an intensive one-week curriculum in prekindergarten whereas the other experimented on how young children learned programming concepts based on the robotics user interface (tangible (TUI), graphical (GUI), hybrid (HUI)) taught in a 9-week robotics curriculum (Sullivan, A., et al. 2013, Strawhacker, A. & Bers, M.U., 2014). In the one-week curriculum, which actually consisted of five days, each lesson was taught by the researchers, with classroom teachers present in order to facilitate classroom management and assist (Sullivan, A., et al. 2013).

5.1.3.1 *''I want my robot to look for food'': Comparing Kindergartner's programming comprehension using tangible, graphic, and hybrid user interfaces*

The study exposed three Kindergarten classrooms to different programming interface styles: tangible, graphical and hybrid, in order to observe differences in children's learning about programming. Each classroom participated in a 9-week robotics curriculum taught by the lead researcher with the help of research assistants (Strawhacker, A. & Bers, M.U., 2014). The curriculum designed following the positive development framework (Bers, 2012), integrated learning robotic programming with the school's standard science curriculum. Children were asked to build a robotic animal and program it to act accordingly to the animal's nature. The three programming concepts in the curriculum were sequencing, repeat loops and creative programming or programming with a goal in mind, introduced sequentially, as each one adds to the last. Children had "buffer" lessons where they could explore without having a specific programming goal in mind. The repeat loops lessons explored actions and sequences that repeated within a program and the final lesson on creative programming encouraged children to choose an imaginative goal for their robotic animal and build a program to execute their goal (Strawhacker, A. & Bers, M.U., 2014).

All children used Lego Education WeDo Construction Sets to build their robots and the Creative Hybrid Environment for Robotic Programming (CHERP) programming language to program the robot's behaviours . CHERP code may be written using an on-screen computer interface where children (GUI group) click-and-drag picture icons of instructions into a list/sequence, for the robot to act out or tangible wooden blocks, where children (TUI group) put together interlocking wooden blocks, with stickers of the CHERP picture icons on the sides. The HUI group were given instructions on both writing styles and were able to pick which one to use (Strawhacker, A. & Bers, M.U., 2014).

5.1.3.2 The Wheels on the Bot go Round and Round: Robotics Curriculum in Pre-Kindergarte

The robotics curriculum, involving approximately 10 hours of work over the course of 5 days was integrated with a larger, exploratory unit on tools that the pre-kindergarten classes were already completing as part of their standard curriculum. The implementation coincided with the school's "Robotics Week," an intensive school-wide experience where all classes are immersed in robotics. The students in the study spent the week focused on designing, building, and programming robotic tools that can assist with the recycling process, hence the engineering design process was a central aspect of the curriculum. The lessons were taught by researchers, with teachers present to facilitate classroom management (Sullivan, A., et al. 2013).

A combination of formal and informal interviews, video, photographs, and classroom observations were used to document the students' experiences whereas classroom teachers were interviewed and asked to complete anonymous pre and post surveys. Eight students were selected from each classroom to participate in formal interviews at the beginning and end of the week, which included questions about the familiarity of the engineering design process and defining words like “engineer” and “robot”. Teachers completed a pre-survey and post-survey as well, including questions about their thoughts on how math and literacy integrated into the curriculum and how much they thought the students learned. Researchers conducted observations paying attention to behaviours, problem-solving strategies, social interactions and expression of ideas while implementing (Sullivan, A., et al. 2013).

5.2 Findings

5.2.1 KindSAR (Humanoid Robot)

KindSAR offers researchers an innovative tool for monitoring various aspects of children’s developmental psychology in a real-time setting, because it can monitor children’s development over time and generate unique data on children’s performance of specific tasks and their responses to specific situations as well as provide both the children and the educational staff with detailed feedback on game/task performance by the children and concurrently monitor their progress over time (Keren, G. & Fridin, M., 2014). A child’s psychological profile, learning style, and social/cognitive developmental stage play essential roles in his/her educational process. The KindSAR robot may be able to provide feedback tailored to each child’s psychological profile, learning style, and cognitive and social developmental stage (Fridin, M., 2013). Furthermore, it minimizes the distractions caused when video recordings are used in the natural environment of children’s games, since KindSAR has its own built-in video recording system (Fridin, M., 2013). Fridin, M. (2013) lays down idea, that “in future research, we will attempt to characterize children’s profiles and to program the robot’s behaviour to fit different types of profiles, i.e., the robot will approach and respond differently according to the profile of each child individually.”

Experiences that arouse emotions have proved to be more memorable than neutral experiences (Caine & Caine, 1994), promoting the idea that affective factors in a learning process are significant. Both experiments (using NAO) showed positive interaction levels suggesting that children enjoyed playing and interacting with the robot (Keren, G. & Fridin, M., 2014;Fridin, M.,2013) contributing that utilizing a robot made the learning process more significant. A good demonstration is that children’s performances were strongly correlated with their interaction levels in one of the experiments (Fridin, M., 2013).

KindSAR is a good tool for constructive learning. The basic principle of constructivist education is that learning occurs when the learner is actively involved in a process of knowledge construction (Keren, G. & Fridin, M., 2014). Vygotsky's sociocultural theory views human development as a socially mediated process in which children acquire their knowledge through collaborative dialogues with more knowledgeable members of society. Vygotsky also views interaction with peers as an effective way of developing skills and strategies, emphasizing the fundamental role of social interaction in the development of cognition. An important principle of Vygotsky's work is the Zone of Proximal Development (ZPD), which is the area where guidance should be given, allowing a child to develop skills they can later use on their own (Vygotsky, L. S., 1978). Freund provided evidence on the operability of the ZPD by conducting a study which concluded that guided learning within the ZPD led to better performance than working alone (discovery learning), an idea that Piaget advocated. Piaget maintains that cognitive development stems from independent explorations in which children construct knowledge of their own (Freund, L.S., 1990; Piaget, J., 1959). "Social assistive technology, given its embodied interactivity and ability to mediate in playing activity, thus has enormous potential as a tool for constructivist educational activities" Fridin, M. (2013, p.55).

5.2.2 KIWI & KIBO Robotics Kit

The ''Solve It'' assessment, which was used in two of the experiments, was administered to measure students' understanding of the programming concepts taught with KIBO. The Solve-It tasks require children to listen to stories about a robot and then attempting to create the robot's program (Sullivan, A. & Bers, M.U., 2018).

In the study done in Singapore, students scored extremely high both mid-test and post-test. Tasks were labelled ''easy'' or ''hard'' based on how many blocks children were required to use to complete the task. Students scored the lowest on the most complex topic, which is predictable, but yet had a mean score of five out of possible six points in all of the tasks. The students' final robotics projects also demonstrated a high level of mastery of the building, construction, and engineering concepts introduced throughout the curriculum (Sullivan, A. & Bers, M.U., 2018). However, this experiment was the first time Solve-It's were tried out outside the US and teachers themselves implemented them instead of researchers (Sullivan, A. & Bers, M.U., 2018), which should be taken into consideration when looking at the high scores.

The other study (which was quite similar to the one in Singapore) done with Solve-It was significant, because it involved children as young as 3 years old. The study showed that children from ages 3 to 5 are able to master sequencing a syntactically correct program, but the more instructions the children were required to sequence, the harder it got. When the children were asked to sequence more than five instructions, the children didn't perform as well as they did when they were required to sequence up to four instructions (Elkin et al., 2016). However, the study proves that KIBO is suitable for children as young as 3 years old but goes to show that younger children do not have enough working memory to hold more than 4 instructions simultaneously in their minds (Shonkoff et al., 2011, Elkin et al., 2016).

The third article looking at KIBO robotics kit by presenting three vignettes illustrated how KIBO integrates with a variety of early childhood education curricula. It was clear that children learned ways to assemble functional robots using sensors, motors and wheels, which was demonstrated whilst each group presented a functional robot and a syntactically correct program by the end of the curriculum (Elkin et al., 2018).

With the KIBO robotics kit children can be storytellers, children get to express their imaginations with code, children get to decide what the robot does and in which order, while learning about sequencing, engineering, coding, cognitive- and numerous other skills. Children get to try out their own ideas. Children get to try and fail and try again. Children get to be the engineers of their own projects and learn important skills of participation and interaction while working in groups to plan, solve problems and negotiate conflicts (Elkin, M. et al., 2016; Sullivan, A. & Bers, M.U., 2018). Dr. Marina Bers explains that "a technology-rich experience for children should be modelled on the idea of a playground. On a playground, children move and explore, they invent games and stories, and they collaborate with peers and negotiate conflict. Most importantly, they lead their own experience (KindLab Robotics, 2018).

5.2.3 LEGO WeDO and CHERP

In the intensive one-week curriculum experiment the results were documented by using video, interviews and observations in addition to pre- and post-experiment surveys. It indicated that children were able to design, build and program a robot after just one week of learning (Sullivan, A., et al. 2013). However, each group received help from an adult researcher and most students were happy with whatever actions their robot performed whether or not it was what they planned. The children were not able to improve their projects without individual help from an adult, nor did they fully understand the concept or programming or robotics (Sullivan, A., et al. 2013). Nonetheless, the interviews indicated that the children's understanding of what engineers do had increased during the week (Sullivan, A., et al. 2013).

In the 9-week robotics curriculum the students' programming knowledge was assessed with qualitative observational data from the classroom (video footage) as well as quantitative mid- and post-test assessment. Quantitative data was collected in the form of Solve-It assessments (Strawhacker, A. & Bers, M.U., 2015). Data collected from Solve It assessments were triangulated with data about the frequency of UI interactions, to determine if there were any significant relationships. In an experiment comparing physical and screen-based puzzles, children aged 7–9 years completed the tangible puzzles faster and with more direct peer collaboration than the computerized ones (Xie et al. 2008), which could suggest that the TUI (tangible) group would succeed better. However, overall analysis of the Solve Its results reveals little difference in scores across the three interface conditions (tangible (TUI), graphical (GUI), hybrid (HUI)) (Strawhacker, A. & Bers, M.U., 2015). This research was a pilot study conducted with three classrooms in the same school setting, but the GUI group was composed of the children aged 5 and up from a larger mixed-age Montessori classroom, because the school only had two age-graded Kindergarten classrooms. The small sample size of all three classrooms makes it difficult to draw conclusions about the results (Strawhacker, A. & Bers, M.U., 2015).

5.3 Challenges

All experiments have challenges. In some, the teachers were more involved than the researchers and thus the teachers' knowledge of how to utilize robotics must be taken into consideration, as well as whether the teacher in question might be biased. The results or overall Solve It scores might have indicated mastery in learning and understanding, but when interviewing the children, they might not have been able to name simple concepts or explain their projects. This puts into question, whether the scores were high because of individualized help from a teacher? Regarding experiment groups, it is hard to prove that all children in the group have the exact same starting point or knowledge regarding engineering and robotics or digital skills in general, which makes it hard to prove that all knowledge was learned during the experiment. Research has shown that children's opportunities to learn from digital technologies and media at home vary depending on how their families interact with technology and media or if the parents frame the use of media. Parents' background, digital skills and attitudes towards technology also impacts children (Kumpulainen, K. & Sefton-Green, J., 2020).

5.4 Conclusions

All studies had positive results and were able to demonstrate that robotics can be utilized in ECE. All studies were quite successful when looking at the result, but of course some studies had challenges concerning the number of participants or the backgrounds of the participant or the teachers being too involved in the scoring process. However, these results brought to our attention multiple wonderful ways of how robotics could be implemented into Finnish ECE. Constructive learning, cognitive skills, multiliteracy skills, metacognitive skills, social skills, participation and skills in engineering and coding can all be promoted with robotics, just to name a few. Not to mention the comprehension of technology, which together with digital and multiliteracy skills is becoming more and more important in this century and has been fully recognized in the Finnish ECEC plan.

6 Information package

6.1 Evaluation of package

Technology education appears to be difficult for early childhood education staff and they consider their own knowledge and skills to be insufficient (Turja, 2017). This was also brought to attention as the information package was discussed with the workers of Pilke Playschool Lehtisaari. Even before the start of the presentation, one teacher voiced out her opinion about robotics (a negative one), which goes to show that teachers have preconceptions about robotics. Three teachers however seemed quite interested in the subject after the presentation. One teacher was quite impartial and didn't voice her opinion.

When asked if the teachers had heard about some robotics being used, some teachers did recognize NAO, but not from a kindergarten classroom, but rather from a healthcare centre, where it has been used to greet people at the entrance. A few workers remembered having some sort of a programming "toy" somewhere, which kind of looked like

KIBO, but no one could actually remember the name of it or where it had been placed, proving that it hadn't been used very often. The reason for its "abandonment" was quite predictable; no one really knew what to do with it or how to use it. The teachers didn't feel it was beneficial in any way (except for maybe play).

The playschool did however have a Bee-Bot, which the teachers said that the children liked to play with, but they didn't always have time for it, since it mandated adult supervision, because of its fragility, if nothing else. The Bee-Bot is a colourful robot designed to resemble a bee and contains keys that can be used to enter up to 40 different commands that children can use to make the Bee-Bot go to different directions. Bee-Bots and ProBots (a similar robot resembling a car), both commercially available robotic toys developed by Terrapin Thinking Tools, are used in schools to teach young children to control the actions of robots (Sullivan, A., et al. 2013). However, they were not chosen to be a part of the literature base for this information package, because they are not merely as advanced as the KindSAR and KIBO and don't offer as much. Compared to these more advanced robotic programs, one could consider the Bee-Bot more like just an instructive toy.

As they were asked if they saw a possibility in them using a robotic kit like KIBO in the future, 3 of them said they might consider it, but only if they had some sort of training first. Not just on how to use it, but also more ideas on how to implement it in the curriculum. An interesting fact was that the newest worker, who was still studying and yet to graduate was able to name more robotic kits and had more information about them than the rest of the staff. She even said that they had some classes about robotic kits, but they were quite superficial, and she said that based on those lessons she still didn't feel ready to try implementing a robotics class, at least not by herself. However, it is positive that the need for students to learn more about technology and robotics nowadays has been recognized and that classes like that have been added to secondary education. In the future, the competence of teachers regarding technology education and STEAM pedagogy must be ensured by adding education to undergraduate program and secondary education (Ukkonen-Mikkola & Varpanen 2020), but most importantly it should be maintained by continuing education. Staff members, whether they just graduated or worked in the for 20 years, should have the same knowledge and competence when it comes to education and pedagogy.

Without convincing teachers about the rewards of robotics, it will never enter into the classroom and its potential benefit to students will not be realized (Cejka, E. et al., 2006).

7 Discussion

It is evident that robotics can be utilized in early childhood education. The field of robotics holds special potential for early childhood classrooms by facilitating cognitive as well as fine motor skills and social development (Bers et al. 2013). Programming robots provides opportunities for supporting all aspects of STEM (Science, Technology, Engineering, Mathematics) and even the new aspect Arts, which expanded STEM to a new acronym “STEAM”. While engaging with technology (T) and engineering (E) design process through programming, children learn mathematics (M) through sequencing and counting and science (S) through exploring cause and effect and conducting observations (Sullivan, A. & Bers, M.U., 2017). Initiating new programs like InnoPlay (conducted in 2018-2021), which aim to develop pedagogical methods for integrative STEAM education (InnoPlay, 2022) proves the importance that STEAM education now has in Finnish ECE. Technology education is a new element in the foundations of the early childhood education plan (OPH, 2018). Information and communication technology (ICT) has been renewed in the National Core Curriculum of ECE to correspond to the modern concept of digital skills. The renewed local ECE plans will be introduced in all day care centers on 1.8.2022 (OPH, 2022). Programming robotics promotes STEAM and ICT learning and could be considered very beneficial in these areas of Finnish ECE. Early childhood is the ideal time to begin teaching engineering concepts because children are naturally inquisitive about the world around them and are motivated to explore, build, and discover answers to their big questions (Bers, M.U., 2018). While programming KIBO, children are involved in an engineering design process. The step of testing and improving is crucial because it forces children to experience failure and move onward, which is necessary for learning (Elkin, M., et. al., 2018).

As mentioned, digital competence is needed for human interaction, learning and being able to function in the society and it is the duty of ECE to support children’s understanding of the digital work in co-operation with the children’s parents (OPH, 2022). It is as important to teach children coding and technology as it was to teach children to write in earlier centuries, because today digital competence is very important for self-expression and participation (KinderLab Robotics, 2018).

Play is significant for learning. Children don't personally see play as a vehicle for learning, it rather motivates them and brings joy while allowing the children to learn skills and acquire knowledge. Children also learn the rules of the community through play which increases sense of community, strengthening a positive emotional atmosphere (National Core Curriculum for ECEC, 2018). As Dr. Marina Bers explained "a technology-rich experience for children should be modelled on the idea of a playground. On a playground, children move and explore, they invent games and stories, and they collaborate with peers and negotiate conflict. Most importantly, they lead their own experience (KindLab Robotics, 2018). With the KIBO robotics kit children can be storytellers, children get to express their imaginations with code, children get to be the engineers of their own projects and learn important skills of participation and interaction while working in groups to plan, solve problems and negotiate conflicts (Elkin, M. et al., 2016; Sullivan, A. & Bers, M.U., 2018). Robotic manipulatives allow children to develop fine motor skills and hand-eye coordination, instead of sitting on a computer, while also engaging in collaboration and teamwork, which builds up their social skills (Lee et al., 2013) as opposed to computer games that have been found to be negatively associated with several health outcomes and the use of computer games can reduce children's social involvement and promote isolation (Hofferth, 2010).

Learning-by-doing is an educational approach with its roots in the theory of Jean Piaget, who claimed that knowledge is not transmitted to children, but is constructed in the children's minds (Siegler, R.S., 1986). The basic principle of constructivist education is that learning occurs when the learner is actively involved in a process of knowledge construction (Keren, G. & Fridin, M., 2014). This constructivism theory is supported when children are programming and building with robotics, providing them a meaningful learning experience, indicating that KindSAR is a good tool for constructive learning. NAO has been shown to have a positive impact on child-robot interaction (Fridin & Yaakobi, 2011). Experiments using a humanoid robot have showed positive interaction levels suggesting that children enjoyed playing and interacting with the robot (Keren, G. & Fridin, M., 2014, Fridin, M.,2013) contributing that utilizing a robot made the learning process more significant.

KindSAR can also monitor children's development over time and generate unique data on children's performance of specific tasks and their responses to specific situations as well as provide both the children and the educational staff with detailed feedback on game/task performance by the children and concurrently monitor their progress over time

(Keren, G. & Fridin, M., 2014). A child's psychological profile, learning style, and social/cognitive developmental stage play essential roles in his/her educational process. As mentioned, for each child in Finland, an individual ECEC plan is prepared, consisting of pedagogical activities and individual objectives and measures for supporting individual development, learning and well-being (National Core Curriculum for Early Childhood Education and Care, 2018). Although there is no performance requirement, teachers are required to observe and document each child's learning, taking into account general objectives established by ECEC curriculum as well as individual objectives (Kumpulainen, K. & Sefton-Green, J., 2020). As such, KindSAR can be used as a monitoring tool, and can be very helpful, considering the children-teacher, whereas the number of children compared to the number of teachers is big enough to make it challenging to observe all children at once. According to the National Core Curriculum for ECEC, the precondition for high-quality pedagogical activities is systematic documentation, evaluation and development (National Core Curriculum for Early Childhood Education and Care, 2018).

Among other competences, multiliteracy has been renewed in the National Core Curriculum for ECE (OPH, 2022). Multiliteracies pedagogy combined with the principles of eco-literacy offer an educational opportunity for the promotion of young children's learning about sustainability-oriented knowledge, skills and empathy for the natural world (Kumpulainen, K. & Sefton-Green, J., 2020). In Finland, the National Core Curricula mandates that formal education should develop children's eco-social knowledge and ability, understanding of human dependence on ecosystems and nurture their knowledge and appreciation of their environment for a sustainable future. The principles of sustainable way of living are implemented in the 3rd transversal competence, which addressed that learning to take care of oneself and to manage daily life is essential (Finnish National Agency for Education, 2022). Teachers are required to promote children's outdoor learning opportunities (Kumpulainen, K. & Sefton-Green, J., 2020). Multiliteracy and ICT competence are also included in transversal competences.

An important positive outcome from adding robotics and engineering in a kindergarten curriculum would be to prevent conception of stereotypes. Research suggests that children who are exposed to STEM curriculum and programming at an early age demonstrate fewer gender-based stereotypes regarding STEM careers (Metz, S.S., 2007). Getting acquainted with robotics at a very young age might be good to fight bias and stereotypes in the future, since the preschool years are considered critical for children's overall development (Chambers & Sugden, 2002).

In research done about gender differences in robotics and programming achievement, results show that boys scored significantly higher than girls in only two areas. These results suggest that girls were equally capable of designing and building functioning structures, and it was only using the added element of robotic parts in which boys outperformed girls (Sullivan, A. & Bers, M.U., 2012). However, in this research we must consider that even the boys who scored higher may have had previous knowledge or experience that helped them achieve better.

KinderLab Robotics (2018) lists 6 key benefits of using Robotics in ECE:
1. Coding teaches the Literacy of the 21st Century
2. Coding Develops Computational Thinking Skills
3. Technology Becomes the Playground
4. Robotics Makes Coding Tangible and Concrete...and Screen-Free
5. Using Technology Breaks Down Engineering Stereotypes
6. The Engineering Design Process Develops Grit and Perseverance

All these benefits could be endorsed. To summon up, using robotics can promote all areas of transversal competences, most importantly Multiliteracy and ICT, but we can conclude that it is beneficial to all areas of Finnish ECE. The ways of integrating robotics into the curriculum are countless, but it does demand imaginativeness and full understanding of operating them on teachers' part to take full advantage of them. The main challenge is to better teachers' competence and knowledge, to draw out all prejudice and invent new ideas on how to utilize them.

7.1 Further Research Recommendations

Teachers' prejudices towards the use of robotics in the classroom and ways to change them should be studied. What kind of education and additional information would teachers need to feel comfortable and confident about utilizing robotics and bringing them to the everyday classroom? It is evident that teachers do not only need operating instructions, but clear guidelines and suggestions on how to integrate robotics.

Technology education appears to be difficult for early childhood education staff and they consider their own knowledge and skills to be insufficient (Turja, 2017). As new types or robotics are being designed to fit the needs of young children it is also important to educate teachers on how to utilize this new technology. Without convincing teachers about the rewards of robotics, it will never enter into the classroom and its potential benefit to students will not be realized (Cejka, E. et al., 2006). Early childhood educators are working with the first generation of children who have had smart technologies in the world since they were born (Kervin, L. & Comber, B. 2020). In the future, the competence of teachers regarding crafts, technology education and STEAM pedagogy must be ensured by adding education to undergraduate programs and maintained by continuing education (Ukkonen-Mikkola & Varpanen 2020).

Lastly, the design and implementation of SAR systems pose several ethical challenges especially in childcare. Some sort of ethical guidelines should be developed on how to “use” a KindSAR in a kindergarten setting.

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Table 1. Included Data.

Included data						
Author	**Publication Date**	**Title**	**Research**	**Tools**	**Results**	**Trust-worthiness**
Guy Keren, Marina Fridin	Elsevier Ltd. 2014	Kindergarten Social Assistive Robot (Kind-SAR) for children's geometric thinking and metacognitive development in preschool education: A pilot study	To show how Kindergarten Social Assistive Robotics (KindSAR) technology could assist kindergarten staff in teaching preschool children geometrical thinking and development of children's metacognition in one set games.	A small humanoid robot Nao.	A robot can assist the teacher in promoting geometric thinking learning through game-like educational activity. Data revealed significant improvement in the children's metacognitive abilities in the second session of the experiment compared to the first.	Yes.
Marina Fridin	Elsevier Ltd. 2014	Storytelling by a kindergarten social assistive robot: A tool for constructive learning in preschool education	How KindSAR can be used to engage preschool children in constructive learning. In this study, storytelling was used as a paradigm of a constructive educational activity.	A small humanoid robot Nao. Video and audio data were collected during the experiment and analyzed.	Our results show that the children enjoyed interacting with the robot and accepted its authority. This study demonstrates the feasibility and expected benefits of incorporating KindSAR in preschool education.	Yes.

Included data						
Author	**Publication Date**	**Title**	**Research**	**Tools**	**Results**	**Trust-worthiness**
Amanda Strawhacker, Marina U. Bers	Springer Science+Business Media Dordrecht, 2014	‘‘I want my robot to look for food’’: Comparing Kindergartner’s programming comprehension using tangible, graphic, and hybrid user interfaces	This study aims to explore how successfully young children master foundational programming concepts based on the robotics user interface (tangible, graphical, hybrid) taught in their curriculum. Thirty-five Kindergarten students participated in a 9-week robotics curriculum using the LEGO WeDo robotics construction kit and CHERP.	LEGO WeDo robotics construction kit and the Creative Hybrid Environment for Robotic Programming - CHERP.	The small sample size of all three classrooms makes it difficult to draw conclusions about the results. Although the results are inconclusive, this pilot study shows that for Kindergarten students, using a tangible programming language may be related to enhanced comprehension of abstract concepts like repeat loops.	Yes.
Mollie Elkin, Amanda Sullivan and Marina Umaschi Bers	Springer Nature Singapore Pte Ltd. 2018	Books, Butterflies, and ‘Bots: Integrating Engineering and Robotics into Early Childhood Curricula	Describing how robotics can be used to learn foundational engineering and computer science concepts. Presenting vignettes from three classrooms that embarked on an eight-week KIBO robotics curriculum. Educators were able to integrate robotics with traditional early childhood content such as literacy and science.	KIBO	Children were able to succesfully program their robots and present complex work by the end of the curriculum. Each group was able to articulate their reasoning behind their programming.	Yes.

Included data						
Author	**Publication Date**	**Title**	**Research**	**Tools**	**Results**	**Trust-worthiness**
Amanda Sullivan, Marina U. Bers	Springer Science+ Business Media Dordrecht 2017	Dancing robots: integrating art, music, and robotics in Singapore's early childhood centers	This study looks at a sample of preschool children who completed a 7-week STEAM KIBO robotics curriculum in their classrooms called ''Dances from Around the World.'' Children's knowledge of programming concepts were assessed upon completion of the curriculum using the Solve-Its assessment. Data was collected on students' programming knowledge at the midpoint and endpoint of curriculum implementation.	KIBO	The Solve-Its were scored on a scale of 0–6 based on how close they were to the correct answer. On all tasks, students had a mean score of 5 or higher, out of 6 possible points (both mid-test and post-test). Results demonstrate a very high level of mastery on all concepts taught.	Yes/No. The results were collected by teatchers instead of researchers which may indicate tht the results may not be 100% accurate.
Amanda Sullivan, Elizabeth R. Kazakoff and Marina U. Bers	Journal of Information Technology Education, 2013.	The Wheels on the Bot go Round and Round: Robotics Curriculum in Pre-Kindergarten	This paper qualitatively examines the implementation of an intensive weeklong robotics curriculum in three Pre-Kindergarten classrooms. The children used CHERP to program "Robot Recyclers" that they constructed using parts from LEGO® Education WeDo™ Robotics Construction Sets. The Robot Recyclers were designed to help carry, push, and/or sort recyclable materials found in the classroom.	CHERP	This study demonstrates that it is possible to teach Pre-Kindergarten children to program a robot with developmentally appropriate tools, and, in the process, children may not only learn about technology and engineering, but also practice foundational math, literacy, and arts concepts.	Yes.

Included data						
Author	**Publication Date**	**Title**	**Research**	**Tools**	**Results**	**Trust-worthiness**
Mollie Elkin, Amanda Sullivan & Marina Umaschi Bers	Computers in the Schools, 2016.	Programming with the KIBO Robotics Kit in Preschool Classrooms	Preschool students partici-pated in a nine-hour introductory ro-botics and programming cur-riculum. Upon completion of the curriculum, students com-pleted a KIBO programming task (called "Solve-It") to as-sess their programming knowledge.	KIBO	For all tasks on the Solve-It assessment, basic descriptive statistics were calculated. On average, the children in this study were highly successful at master-ing basic programming con-cepts after completing the curriculum. Preschool chil-dren in the study, ages 3 to 5, were able to successfully master sequencing a syntac-tically correct program.	Yes.

Table 2. Inclusion and Exclusion of Data

Inclusion Criteria	Exclusion criteria
Published between 2011-2021	Published less than 10 years ago
Relevant to research questions	Not relevant enough
Addresses Early Childhood Education	Addressed higher Education
Trustworthiness/ Trusted source and publisher	Untrustworthy source/ publisher