DESIGN, DEVELOPMENT, AND IMPLEMENTATION OF CT ACTIVITIES FOR PRESCHOOL CHILDREN

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Rana CHAIKH

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Approval of the Graduate School of Educational Sciences

Assist. Prof. Dr. Enisa Mede
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Arts.

Assist. Prof. Dr. YavuzSamur
Coordinator

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Arts.

Prof. Dr. Tufan ADIGÜZEL
Supervisor

Examining Committee Members

Prof. Dr. Tufan ADIGUZEL	(BAU,)
Assist. Prof. Dr. Seda Saraç	(BAU,)
Assoc. Prof. Dr. Tuncay Sevindik	(YTU,)

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name : Rana, Chaikh

Signature :

ABSTRACT

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Chaikh, Rana
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CT has become an essential skill in this era due to the rapid change in technology which demands the individual to enhance his ability to think clearly and rationally. CT skills enhance different skills such as problem-solving, communication, creativity, and analytical thinking. Moreover, individuals who possess CT skills do better later in work life. Due to the importance of such skills, this study proposes designed CT activities for preschoolers. Although various studies have been conducted on this issue, the literature still lacks developed activities which teaches CT skills for preschoolers.

This research investigates the process of designing, developing and evaluating a new designed CT activity which teaches different disciplines (Maths, Science, Technology and Engineering) for preschoolers. This development research followed different stages on instruction respectively: instructional problem, learner analysis, task analysis/ instructional objective/ instructional strategies/ content analysis/ instructional development and evaluation. Qualitative and quantitative data have been collected through interviews with the ECE Expert, instructional designer and subject matter expert, and an observation technique has been used to collect the data throughout 10 sessions. Fifteen preschoolers and two teacher assistants have been also involved in both data collection, implementation, and evaluation of the instructional design process.

It has been found within the scope of the needs analysis that teaching CT skills in Turkish preschools is still a topic that has been ignored, moreover preschool teachers lack the knowledge on techniques to teach and assess CT skills for children at an early age. Another result has revealed that teaching CT skills at an early age has a positive effect on the child’s progress later in primary and secondary school. Additional results from the learner analysis process have shown that children at an early age lack essential CT skills, and such skills can be improved if proper activities and tools are given to the child. From the skills analysis schema, the result has shown that following systematic strategies in teaching CT skills within the scope of task analysis/ instructional objective contribute to significant improvement. Moreover, in this study, the high quality produced resources aim to motivate children to learn and enhance their skills in a playful and friendly atmosphere. However, the ECE Expert has found that the designed activities must be redesigned and reshaped to match three-years-olds’ cognitive and motor skills since it has been found that such designed activities are more appropriate for children starting from age four, and excellent for age five students. The subject matter expert, instructional designer, and researcher have found a positive outcome in the achievement and performance of the children.

In conclusion, this study aims to investigate the ability to design new activities which enhance children’s CT skills by meeting the learning needs of preschoolers in Turkey. This study can also be considered as a guide for the process of instructional design, development, and evaluation of preschool children.

Keywords: CT, 21.Yy Skills, Preschooler Education, Design-Based Research, Educational Technology.

ÖZ

Rana Chaikh

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BT günümüzde bireyin rasyonel düşünme yetisini geliştirmesini gerektiren hızlı teknolojik değişimler ve gelişmelerden dolayı BT her birey için sahip olması gereken bir beceri olmuştur. BT skills problem çözme, iletişim,yaratıcılık ve analitik düşünme gibi bir çok farklı beceriyi geliştirmektedir. Ayrıca, BT becerileri gelişmiş bireyler iş hayatlarında daha başarılı olmaktadırlar. Bu becerilerin önemi doğrultusunda, bu çalışmada okul öncesi öğrencileri için BT aktiviteleri tasarlanmıştır. Alanda bu konuda bir çok çalışma olmasına rağmen, okul öncesi öğrencilerine BT becerilerini öğretecek ve geliştirecek aktivitelerin azlığı göze çarpmaktadır.

Bu araştırma, farklı disiplinleri (Matematik,Fen,Teknoloji ve Mühendislik) öğretmek amacıyla tasarlanan bir BT aktivitesinin tasarlama, geliştirme ve değerlendirme süreçlerini incelemektedir. Araştırmada sırasıyla öğretim problemi, öğrenci analizi, görev analizi/öğretimsel amaç/öğretimsel stratejiler/içerik analizi/öğretimsel gelişme ve değerlendirme aşamaları takip edilmiştir. Nitel ve nicel veri hem EÇE uzmanı,öğretimsel tasarımcı ve konu uzmanı ile yapılan görüşmelerden hem de 10 oturum boyunca veri toplamak için kullanılan gözlem tekniği ile elde edilmiştir. 15 okul öncesi öğrencisi ve iki öğretmen asistanı öğretimsel tasarım sürecinin veri toplama, uygulama ve değerlendirme aşamalarına dahil edilmiştir.

Yapılan ihtiyaç analizi kapsamında Türkiye'de okul öncesi eğitim kurumlarında BT becerilerinin öğretilmesi konusunun göz ardı edildiği dahası okul öncesi öğretim kurumlarında çalışan öğretmenlerin bu yaş grubundaki çocuklara BT becerilerinin

öğretilmesi ve değerlendirilmesi konusunda yeterli donanıma sahip olmadıkları görülmüştür. Başka bir sonuç ise çocukların erken yaşta BT becerileri kazanması onların ilkokul ve ortaokul eğitimlerindeki gelişmelerinin üzerinde olumlu etkilere sahiptir. Öğrenci analizleri sonuçları ise çocukların erken yaşlarda BT becerilerine sahip olmadığını ancak bu becerilerin uygun aktivite ve araçlarla geliştirilebileceğini göstermiştir. Ayrıca yetenek analizi şeması sonuçları, görev analizi/ öğretimsel amaç kapsamında BT öğretiminde sistematik stratejiler takip etmenin gözle görülür gelişmelere neden olduğunu ortaya koymuştur. Bu araştırma için üretilen yüksek kaliteli kaynaklar, bu kaynakların çocuklara rahat ve neşeli bir ortamda sunularak onların bu becerileri öğrenme ve geliştirme konusundaki motivasyonlarını artırmayı hedeflemektedirler. Ancak, ECE uzmanı bu kaynakların 3 yaş grubu çocuklarının bilişsel ve motor becerileri göz önünde bulundurularak yeniden tasarlanıp şekillendirilmeleri gerektiğini belirtmiştir. Bunun nedeni üretilen bu aktivitelerin çocuklar için 4 yaş ve sonrası daha uygun ve 5 yaş grubu çocukları için ise mükemmel olmalarıdır. Konu uzmanı, öğretimsel tasarımcı ve araştırmacı çocukların başarısı ve gösterdikleri performansta olumlu sonuçlar gözlemişlerdir.

Sonuç olarak, bu çalışma Türkiye'de bulunan okul öncesi eğitimi alan çocukların ihtiyaçlarını karşılayarak onların BT becerilerini geliştirecek yeni aktiviteler geliştirme konusunu incelemektedir. Bu çalışma aynı zamanda okul öncesi öğrencileri için hazırlanacak olan öğretimsel tasarım, bu tasarımın geliştirilmesi ve değerlendirilmesi sürecinde bir rehber olarak ele alınabilir.

Anahtar kelimeler: BT, 21. yüzyıl becerileri,Okul Öncesi Eğitimi,Tasarım Temelli Araştırma, Eğitim Teknolojisi

This work is dedicated to my lovely mother, who passed away three years ago. You inspired me to continue my education; I cannot forget your advice about being creative and unique. This is my first journey for higher education. Moreover, I will make your dream comes true.

I love yo

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LIST OF ABBREVIATIONS

ADDIE	Analysis, Design, Development, Implementation, Evaluation
CT	Critical Thinking
CLA	The Collegiate Learning Assessment
DBR	Design Based Research
DR	Development Research
ECE	Early Childhood Education
ECE	Early Childhood Education
EPPSE	Effective Preschool, Primary and Secondary Education
EU	European Union
ISD	Instructional System Design
PISA	Program for International Student Assessment
SME	Subject Matter Expert

Chapter 1
Introduction

1.1 Overview

Educators, experts, and business leaders have identified a particular set of skills as requirements for success in today's evolving world, which also motivates educational institutions to develop or adopt rigorous programs that work towards fostering such necessary skills for students. The set of skills is commonly referred to as the 21st-century skills (see Table 1). Supporters of the integration of the 21st-century skills in educational systems have deemed those skills as necessary ones when preparing students to societal needs (Claro & Ananiadou, 2009). The 21st-century skills are divided into three categories: (a) The learning and innovation skill which prepares the student for a real-life complex task, (b) Information media and technology skills. Since we live in a technological and media-driven environment that is changing rapidly, individuals should be able to adapt to change. (c) Life and career skills which are necessary to navigate a complicated life and work environment (Choo, Tan., Kang & Liem, 2017).

Table 1

21st-Century Skill

Learning and innovation skills	Creativity and innovation CT and problem solving Communication Collaboration
Information, Media and Technology skills	Information Literacy Media literacy ICT (Information, Communications, and Technology) Literacy
Life and Career Skills	Flexibility and Adaptability Initiative and Self-Direction Social and Cross-Cultural Skills Productivity and Accountability

One prominent factor that researchers have shifted their attention to is Critical Thinking (CT) (Ricketts, 2003). Even though CT is a part of the 21st-century skills, the concept has been long discussed in terms of its proper and effective implementation in the field of education (Feldman, 2002). According to Chun (2010), and Yancher, Slife, and Warne (2008), CT has various conceptual definitions, and one clear definition has not been provided. Chun (2010) provides a general definition of CT "as a form of higher order thinking along with analytic reasoning and problem-solving" (p. 2). Paul and Elder (2008a) define CT as analysis and evaluation of thinking processes. Nickerson, Perkins, and Smith (2008) speculate that CT is a method of thinking that incorporates rationality and is heavily grounded in that. In this study, the notion of CT is defined as a thinking method that aims at improving one's quality of thinking while employing higher-order skills such as evaluation, analysis, and synthesis (Courtney, Simpson, 2002).

According to Ennis (2007), CT skills are essential in the work domain; however, the graduates still lack CT skills. That is why, CT has become one of the most critical skills that employers expect from the graduates (Hart, 2010) and educators are encouraged to teach CT skills at early ages to shape the lifestyle of the society (Aizikovitsh & Cheng 2015), this in turn incorporates fostering essential twenty-first-century skills among preschool learners.

Current education systems in the majority of developed countries have been recently paying more attention to preschool education (Rubtsov & Yudina, 2018). Those delicate years in a student's life are the foundation on which every other learning experience is built upon. Preschool education provides children with long-learning benefits, which may include the following: (1) a longer attention span which improves focus in a classroom setting, (2) advanced language and social skills, and (3) the ability to adapt to different structural activities and schedules. Accordingly, "preschool students are encouraged to explore, investigate, and experience" (Bell, 2010, p. 42).

Piaget (1948 [1973]) suggests that educators should encourage children to think critically without being obedient to others. He also discusses that the children should have the ability to decide independently and distinguish between right and wrong without thinking of reward or punishment. When students think critically, they will be able to approach the world reflectively (Brookfield, 1987). Preschool teachers encourage students to gain CT skills by asking questions, playing freely, reading books, attending art classes and meal time (Foorman & Torgesen, 2001). On the other hand, more CT skills can be gained in the classroom by dealing with real-life problems, which encourages discussion and fosters inquiry-oriented experiments (Miri, David & Uri, 2007).

The role of the teacher is not limited to the development of students' understanding of the subject matter. In other words, the teacher helps students become independent learners and acquire CT skills, which enables them to adapt to different situations, manage conflicts efficiently, logically, analytically, and systematically as well as making use of the learned material in authentic encounters (Bransford, Brown, & Cocking, 2000). Consequently, students are not provided with facts, but with transferable skills that will assist them in dealing with various societal needs and circumstances (Al-Madhoun, 2004). With the aim of solving the aforementioned problems and meeting the needs, activities should be designed, developed and tested to make an impact on preschoolers' CT skills which are chief skills that ought to be taught at early stages in the learning journey.

1.2 Statement of the problem:

According to Gierco (2016) and Hooks (2009), educators advocate the need to implement CT skills within the curriculum, primarily due to the swift development in technology that today's era is encountering. By promoting such a CT curriculum, students will have the ability to adapt to change and to resolve authentic situations through effective and innovative methods. Nonetheless, this unrelenting demand has posed several challenges. Schools have not yet been able to equip learners with effective CT skills that enable them to survive multiple societal encounters (Wagley, 2013). Facione (2010) claims that even though CT is highly regarded as a skill, students still fail to think critically. According to Mergler & Spooner-lane (2012), this could be due to different factors and teaching methodologies are among them. Through practical teaching and learning strategies, teachers can prompt students to actively engage in CT (Mergler & Spooner-lane, 2012). Miri, Ben-Chaim, and Zoller (2007) also propose explicitly teaching CT to ensure success and acquisition of skills.

According to Smith and Szymanski (2013), less attention has been paid to teach CT skills in preschools, leaving young learners to lack the necessary skills to succeed in higher education. Researchers have suggested that a more in-depth focus on teaching CT skills for preschoolers are needed (VanTassel-Baska, Bracken, Feng, & Brown, 2009; McCollister & Sayler, 2010; Snodgrass, 2011; Tsai, Chen, Chang, & Chang, 2013), Provided that CT skills can be gained by utilizing activities that enhance CT skills, students better understand what is going around them by linking these experiences with their surrounding (Tsai et al., 2013).

1.3 Purpose of the study:

The purpose of this study is to design, develop and evaluate the activities that were designed to enhance CT skills among young learners by using the stages of instructional design. The aim of these activities is to enhance young learners' CT skills with the help of activities designed with the latest technology to cope with the 21th century skills.

Education stresses the importance of teaching CT skills, for both academic achievement and career, in other words students are expected to question the validity of information instead of copying it (Alagozlu, 2007). In the past, obtaining knowledge which was transferred mostly from teachers and books was enough. However, one of the purposes of education today is to encourage the learners to acquire knowledge and analyze them through questioning and reasonable judgment. Hence, educators suggest that to shape the new generation CT starting at an early age is important, and this can be achieved when CT is integrated into the curriculum (Han & Brown, 2013). In other words, CT can be integrated in lessons throughout all disciplines by utilizing questioning and evaluation of both data and sources in depth (McCollister & Sayler, 2010).

1.4 Significance of the study:

In this era, CT has become an essential skill that should be taught starting at a young age in schools. Hence, students who gain CT skills can know how to think, not what to think. Moreover, teaching CT in preschools has been given much discussion without action (Watanabe-Crockett, 2015). In Singapore preschools, which are rated among the best in the world at reading, math, and science, where students are taught CT skills (Johnson & Christensen, 2008). In Turkey, preschools still lack activities that enhance CT skills (Ministry of National Education, 2012 [21]).

This study is essential to the instructional design since it will add the notion of implementing CT skills into the instructions of educational research. A topic that is still discussed among scholars is the design and assessment of CT skills (Arum & Roksa, 2010). Therefore, the results that this study intends to achieve contribute significantly to preschool education as it solely focuses on those early learning years. Hence, the findings of this study suggest a need to rethink how CT skills should be taught and assessed. Moreover, the study tests and validates the CT activities that have been designed by the researcher using high technology aligned with CT skills. This study also adds expertise to preschool teachers by providing them with a complete lesson plan that includes CT skills. Furthermore, the study aims at raising awareness on how young learners can understand and develop their skills — contradicting the idea that they are very young to understand the world around them.

The notion that the proposed study follows a design-based implementation research accentuates its aim to realize a useful and novel approach to teaching and learning, whereby CT is highly regarded. Moreover, the study supplements the already existing literature body by adding more insights into CT activities and their implications on CT skills among preschoolers.

1.5 Hypotheses and Research Question

This study aims to answer the following questions by using designing, developing and evaluating ten CT activities lessons using the ADDIE instructional design model.

1- What are the needs and instructional goals of designing CT activities for preschoolers?
2- What are the characteristics of preschoolers participating in the instructional activities to foster their CT?
3- What are the CT assessment and evaluation criteria for preschoolers?
4- How are the instructional activities to foster CT of preschoolers developed?
5- How are the objectives of the activities aligned with CT skills and sub-skills to foster CT skills for preschoolers designed?
6- How are the instructional activities to foster CT of preschoolers validated?
7- How are the instructional activities to foster the CT of preschoolers implemented?
8- What are the outcomes of the implementation of the instructional activities to foster CT of preschoolers?
9- What are the Perception of preschoolers towards the instructional activities to foster their CT?

1.6 Definition of terms

CT. According to Paul and Elder (2007), "CT is the art of analyzing and evaluating thinking with a view to improving it" (p. 4).

Design based research: According to Wand and Hannafin (2005), DBA is a systematic but flexible methodology aimed to improve educational practice through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in a real-world setting, and leading to contextually sensitive design theory and principle.

Layered curriculums. According to Akran and Uzum (2018), layered curriculums divide the entire curriculum into three layers, and each layer includes a grouping of assignments that represents a different depth of study and requires students to use a variety of skills and intelligence.

Problem based learning (PBL). According to Finkle and Torp (1995), PBL is a curriculum development and instructional system in which a complex real world problem is being used, to push the students to learn, and promote their CT skills.

Virtual reality (VR). According to Bradi (2019), VR is "the use of computer technology to create a simulated environment. Unlike traditional user interfaces, VR places the user inside an experience. Instead of viewing a screen in front of them, users are immersed and able to interact with 3D worlds" (p. 8).

Chapter 2

Literature Review

This chapter reviews the available research on the proposed topic. Primarily, two main topics were reviewed in detail, CT (CT) and Preschool education, with a subtopic that is related to the study.

2.1 The twenty-first-century skills and CT

Changing demands for modernization and discovery (Trilling & Fadel, 2009) and the emergence of information and communication technology have necessitated the development of specific critical skills among younger generations (Dede, 2010). Those skills are not derived from previously set standards or curricula; in fact, the skills emerge from lived experiences (Binkley, Erstad, Herman, Raizen, Ripley, Miller-Ricci, & Rumble, 2012). Those skills are known as the 21st-century skills (Dede, 2010). Researchers have focused their attention on those skills, classifying individuals who possess them as those with more significant advantages when compared to individuals who do not (DiBenedetto, 2018).

Even though there are multiple ways to identify the exact meaning and components of the 21st century skills (Dibenedetto, 2018; Larson & Miller, 2011), they are still thought as prerequisites for individuals to be able to function effectively as citizens and to handle work and life pressures (Ananiadou & Claro, 2009; Kalantzis & Cope, 2008). The twenty-first-century skills incorporate a wide set of skills that vary from one researcher to the other. Duncan (2009) claims that these skills encompass the ability to think and solve problems creatively, persevere in assigned tasks, and perform effectively as part of a team. DiBenedetto (2018) seconds Duncan (2009) and asserts that our progressive system requires individuals to think critically, produce innovative solutions, and solve problems effectively, all while maintaining and bringing creativity into their daily encounters. Those skills do not require learners to acquire the knowledge passed on to them passively but to engage with the knowledge and apply it to authentic situations (Larson & Miller, 2011). In this regard, Larson and Miller (2011) believe that acquiring those skills is only evident when each of them are integrated with educational curricula rather than being taught in separate entities. Furthermore, DiBenedetto (2018) associates those skills to opportunities with "lifelong employability and lifelong learning" (p. 2).

Since the 21st-century skills are vast in terms of scope and breadth, one particular skill has been examined for this study. Costa (2001) accentuates that the revolution in the 21st century, especially in the field of education, stresses on the proper and effective use of the CT process. Even though researchers have long discussed this, it remains a prominent one in the field (McPeck, 2016). Moreover, education has always identified one of its primary goals as having learners acquire effective CT skills (Hitchcock, 1983).

Dewey (1910) first coined the term CT as a process of reflective thinking, and he defined it as an "active persistence and careful consideration" of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends (Dewey, 1910, p. 6). Ever since Dewey's (1910) definition of CT emerged, researchers and social scientists have been building on and adding on to what CT means with a more practical attempt to concretize the abstractness that CT possesses. As the name explains, CT refers to a particular mode of thinking about any problem, whereby the individual improves the quality of his/her thinking process through using higher-order skills, such as analyzing, synthesizing, and evaluating. That being said, according to the research conducted, there appears to be various definitions of CT (Erwin & Sebrell, 2003; Halpern, 2013). According to Lewis and Smith (1993) CT is how people think and solve problems. Sternberg (1986) defined CT as a mental process that people use to solve a problem, make a decision and learn. Halpern (1998) defined this term as "the use of those cognitive skills or strategies which enhance the probability of a preferred outcome."

Jones, Dougherty, Fantaske, and Hoffman (1997) have conducted a study that aims at identifying an agreement on defining CT. They have concluded that CT is broad and it encompasses logical thinking about a situation with an open mind and a target to uncover limitless solutions. Moreover, according to Fischer and Spiker (2000), most definitions of CT include the following: (1) thinking logically, (2) judging, (3) reflecting, (4) questioning, (5) metacognition, and (6) mental processes. Therefore, in essence, CT draws attention to cognitive skills in order to yield anticipated outcomes. Halpern (2013) describes this thinking as "purposeful, reasoned, and goal-directed" (p. 9). Hence, a critical thinker not only passively thinks about his/her thought processes but also does so in a careful and effortful manner. One definition to CT that stands out is that of McPeck (2016), who has approached the concept of CT in his book in a contemptuous manner: an individual who critically thinks has specific characteristics that involve skepticism towards what has been given. Consequently, a critical thinker does not take things at face value and assume that they are right just because he/she has read them somewhere. A critical thinker questions the credibility behind given statements and situations and seeks to find answers that satisfy his/her thought processes. This use of cynicism is equipped with experiences and experimenting and is not built on non-evidence-based opinions and notions. Nonetheless, McPeck (2016) also clarifies that raising endless questions and engaging in skepticism do not lead to CT. He instead invites individuals to engage in a process which he called "reflective skepticism." That is, "we may say of someone that he is a critical thinker about X if he has the propensity and skill to engage in X (be it mathematics, politics or mountain climbing) with reflective skepticism" (p. 7). For this study, the adopted definition of CT is purposeful thinking, whereby learners employ intellectual criteria and standards while thinking about the problem and situation in hand (McPeck, 2016).

Even though CT is only one of the skills related to the twenty-first-century skills, it is still a broad concept in itself and has various sub-skills that need to be regarded. According to Facione (2015) and Lai, DiCerbo, and Foltz (2017), CT has cognitive and dispositional dimensions. Both sets of dimensions are rooted at the core of thinking critically. Some cognitive dimensions include analysis, synthesis, and evaluation among others. Dispositional dimensions include, but are not limited to, open-mindedness, flexibility, and inquisitiveness. Those dimensions are significant in number, and each has its definition, means of implementation, means of assessment, and limitations. However, for the purposes of this research, only five dimensions, a combination of both cognitive and affective ones, are looked into (Facione, 2015): (1) Analytical, (2) Communication, (3) Creativity, (4) Open-mindedness and (5) Problem-solving.

2.1.1 Developing CT capabilities

Developing CT capabilities necessitates the presence of enriching activities where students are provided with a space to construct their learning journeys (Erickson, 2006). Those activities can be, but are not limited to, discovery-based activities, inquiry-based activities, experiential activities, and problem-based activities. With those activities being conducted, educators should bear in mind that students need to be given an adequate amount of space and time to be able to complete the assigned activities (Salmon, 2010).

The assumptions that underlie the above-mentioned activities require students to work on resolving an authentic problem or obtaining information while relying on and building upon their previous knowledge and experiences (Kirschner, Sweller, & Clark, 2006). By doing so, students can uncover the new information and construct their own experiences (Kirschner et al., 2006). With minimal guidance, students make use of what has been previously acquired and their learning styles to attain the objectives that the given tasks require (Bernstein, Penner, Clarke-Stewart, Roy & Wickens, 2003).

Following this approach in teaching and learning provides better chances for students to retain information, especially at such an early age in preschool. Bok (2006) argues that passively taking in information and memorizing factual data do not ensure that students are going to remember what they have already learned. Nonetheless, engaging in a particular activity cognitively where interests are sparked increases the likelihood of acquiring the learning objectives. Moreover, Rogoff (1990) accentuates that students learn more complex skills when little formal instruction is given; therefore, students are required to participate in real-life activities, observe and study real events, and formulate discussions with others.

The points above have long been discussed by psychologists and educators. These learning strategies date back to the 1950s, and Piaget (1952) proposed that students should be the center of the learning process; consequently, teaching and learning should be student-centered as opposed to the traditional teacher-centered approach. Hence, while developing CT capabilities, the educator needs to be aware of the enormous role that the student plays in developing his/her skills. Therefore, instead of constructing activities that focus around the teacher doing most of the work and most of the learning, the students should be guided into a learning phase, whereby they work on nurturing their skills through engaging in authentic, mind-stimulating, and challenging activities (Gopnik, Glymour & Schulz 2007).

However, and most importantly, the activities that support discovery learning and that need to be created in order to develop CT should not be devised haphazardly. Therefore, the teacher should work towards providing meaningful guided tasks. According to Alieri, Brooks, Aldrich, and Tenenbaum (2011), discovery tasks that lack adequate guidance yield minimal results as opposed to enhanced guided tasks. In their study, they conclude that when students are given time to be actively engaged and to discover new information, learning reaches its optimal stage. That time also provides students with an ability to amplify necessary CT skills.

2.1.2 Assessing CT

While many educators believe that developing CT of their students is of primary importance (Albrecht & Sack, 2000), few have an idea about exactly what it is, how it should be taught, or how it should be assessed (Paul, Elder & Batell, 1997). The most effective way to assess CT is to use an authenticated CT test and to use a CT mindset measure to assess the level of the person’s motivation and enthusiasm (Scriven and Paul, 2004). Hence, to assess CT skills for the students, educator should first provide students with many ways to engage in the upper levels of Bloom's taxonomy where CT takes place (Hatcher & Spencer, 2005).

According to Harris and Hodges (1995), CT assessment can be tricky to perform because it embraces broad skills. However, we can begin to assess CT by breaking it down into more basic components and then determining the criteria that can be used with the learners (Harris & Hodges, 1995). Therefore, rubrics used to assess CT should be based on the stages of Bloom's Taxonomy, which can be used either by the teachers or by students for peer assessment (Duron, Limbach & Waugh, 2006).

2.1.2.1 Assessment tools for CT skills

Many standardized assessment tools have been developed to assess CT skills. However, the most widely used tests are (1) the Watson-Glaser CT Appraisal (Watson & Glaser, 1925), (2) the Ennis-Weir CT Essay Test (1985), (3) the California CT Skills Test (Facione, 1990), (4) the California CT Disposition Inventory (Facione & Facione, 1994) and (5) the Collegiate Learning Assessment (CLA) Program (2002).

The Watson-Glaser CT Appraisal consists of multiple-choice questions to assess CT skills in five dimensions, assumptions, inferences, 16 interpretations, education, and evaluation of arguments. The target audience of this scale is adults. The Ennis-Weir CT Essay Test was developed by Ennis and Weir (1985) to measure CT ability. The test comes in the form of letter which consists of eight paragraphs. The test takers are first supposed to read and then write an essay. The essay is to evaluate each paragraph and the whole letter afterwards. The target audience is high school and college students. California CT Skills Test was developed by Facione (1990), which consists of multiple-choice questions categorized according to difficulty and complexity. Moreover, it consists of a short text where the test taker should evaluate, analyze and interpret the information. The target audience is graduate and undergraduate students.

The California CT Disposition Inventory was developed by Facione and Facione (1994). The test aims to assess different skills of test takers in regards to CT skills. These skills are open-mindedness, systematicity, inquisitiveness, self-confidence, truth-seeking, analyticity, and maturity. The target audience is adults. The Collegiate Learning Assessment (CLA) Program is an assessment tool, that target college student, the assessment tool employs a performance task which consists of an exercise that requires learners to apply a different skill of CT and employ their communication skills in order to solve a complex problem. To do so, learners are given one hour to examine a set of documents and propose a solution to the problem mentioned in the task.

Although various assessment tools have been created, none of them seems to be adapted to test CT skills among preschoolers. Therefore, there is a need regarding this in the literature. Nonetheless, the most appropriate technique to assess preschoolers' CT abilities lies in documenting (Hognestad, 2010). According to Hognestad (2010), documentation is the primary step in realizing CT among preschoolers. Through documentation, the teacher can record students' interactions in the classroom. Those documentations could be in the form of recorded-interactions, videotapes, anecdotes, and photographs as well as others. Both the teachers and the students could make use of those instances to reflect on and evaluate their teaching and learning (Kristoffersen, 2006). The standards that the teacher puts in place while assessing CT skills through documentation should (Binkley, Erstad, Herman, Raizen, Ripley & Rumble, 2010) have aligned goals, possess adaptability to different situations, be based on performance, have added value on learning, ensure that students portray visible thinking processes, be fair, be valid, provide information-rich learning experiences, and have the ability to be constructively criticized.

Despite the availability of a wide variety of published CT assessment scales, educators may want to design their assessment of critical-thinking skills such as homegrown assessments. Homegrown assessments are linked with particular learning objectives. They are accompanied with the precise characteristics of critical-thinking that the teachers want to achieve. Also, as homegrown assessments are implemented in a specific discipline, they give a more accurate measure of CT. The evidence-centered design gives an organized outline for creating assessment tasks to stimulate targeted skills (Mislevy, Steinberg & Almond, 2003). Moreover, performance assessment which is known as alternative or authentic assessment requires students to perform the task instead of answering a set of questions or multiple-choice exam and to work based on an agreed set of criteria. This new form of assessment has been widely adopted in the United States (Elliot, 2011).

2.2 Pre-school Education

2.2.1 Preschool education background

There is an excellent focus on the importance of early childhood education (ECE) all around the world since children who attend ECE tend to perform better than those who do not (Heckman, Stixrud & Urzua 2006; Sylva et al. 2012). Evidence from different disciplines such as neuroscience, education, economics and development psychology suggests that there should be more investment on preschool education, claiming that children who attend preschool develop capabilities on which subsequent development builds (Shonkoff & Phillips 2000, p. 5). Moreover, according to Kowalski, Pretti-Frontczak and Johnson (2001), preschool education is not only limited to literacy, language, and math but also the most critical skills that children will learn is social and emotional skills. Besides, early learning is essential as a preparation for effective education which promotes social welfare and social order, and it develops a world-class workforce (Ball, 1994). Therefore, ECE plays an essential role in building children's academic performance and developmental process.

The Effective Preschool study that was conducted in 1997, which was funded by the government of the UK, Primary and Secondary Education project (EPPSE), was designed to evaluate the effect of preschool on children's academic and social-behavioral outcomes. The study was conducted on 3,000 children attending English preschools to 380 children that did not attend preschool. Two recent significant evaluations, EPPSE 3-14 (Sylva et al. 2012) and EPPSE 3-16+ (Taggart et al. 2015), found a positive result between preschool attendance and a range of cognitive and non-cognitive outcomes (Taggart et al., 2015). It was also concluded that children who attended preschool showed high performance at school and later throughout their career.

2.2.2 Learning and Teaching in Pre-school

Childhood education involves many theories and facts, educators around the world have created a different style of teaching, quoted from Jean Piaget studies with children (Hinitz & Lascarides, 2013) (see Table 2 which represent Theories of teaching). Early childhood classes provide the children with an environment to play, learn, gain social skills and have fun. One way that children can learn is through play and this can be applied to activities in order to teach math, science, art, writing and reading (Santer & Griffiths, 2007). Children develop their cognitive, emotional, physical, and creative skills through playing by exploring their surrounding (Stegelin, 2005). Moreover, their communication skills are developed by interacting with other children. Hence, this results in developing their problem-solving skills using their imagination and creativity to learn (Stegelin, 2005).

Table 2

Theories of Teaching

Method	Focus
The Montessori Method	The main focus is always to be attentive towards children and follow them in the direction they choose to go while learning
Reggio Emilia Approach	Children's symbolic language and the context of project-oriented curriculum
Play-Based Learning	Children lead themselves through problem solving and discovery with minimal intervention and learn by playing.
Direct Instruction	The goal for children is to be directed through their development by teachers who lead activities towards specific learning

2.2.2.1 Incorporating play in the classroom

According to Broadhead (2006), children learn while playing, since they use their imagination, and the learning process can occur while they are with other children or on their own. He also suggests that educators use observation and reflection among children to promote the appropriate practice. Furthermore, adding real-life experience carefully depending on the age group, toys should challenge the kids and enhance their skills, and that should match their ability to keep them motivated rather than frustrated (Stegelin, 2005).

While playing, not only children's knowledge expands but also their skills improve; for example, children learn to share and wait for their turns. They also sharpen their cognitive skills, which means when the teacher provides challenging materials such as toys in sand, they start to explore and communicate with their peers and teachers when they get excited (Honig, 2007). Moreover, children improve their CT skills while playing (Honig, 2007). The role of the educators is to set up an environment that encourages meaningful play (Howard, Jenvey & Hill, 2006). Hence, to make learning effective, children need an appropriate amount of time and open-ended material available for them, what is more, the teacher should link constructive play in the classroom such as dramatic play (Drew et al. 2008).

2.2.2.2 Fine arts in preschool

Learning among preschoolers can be optimized by adding fine arts such as music, art, and dance in their curriculum (Young, 2008). Armistead (2007) focused on a study conducted in Philadelphia to evaluate the effect of introducing a program that teaches music and other fine arts skills to preschool curriculum for 3-5-year-old preschool children. The number of children, the class organization, and the quality of the instrument were taken into consideration. The aims within the program were structured equally to foster children's artistic abilities. The result of the study showed that children who attended preschool with the above-mentioned program were able to identify patterns independently, in other words, the physical, auditory, and visual works were able to enrich children's skills.

2.2.2.3 Math and Science in preschool

Children's interest in counting and numbers emerge even before starting their formal education. Lock and Gurganus (2004) proposed that children can develop counting skills through various ways such as counting blocks, literally seeing small quantities and adding small numbers in order to develop their understanding about counting. Children should touch objects and count them since number sense in mathematical development is similar to phonemic awareness in reading (Doucet & Tudge, 2004). Moreover, young children are highly motivated to work with numbers and enjoy counting activities on their own. However, children improve a better understanding when they have the opportunity to engage in numeric activities on a daily basis in a playful atmosphere in a school setting (Ginsburg et al. (2006).

Preschoolers have a great ability to develop the knowledge of counting and quantity, especially while babies grow into toddlers, which is evident in the work of different scholars, Lai and Mix (2006). Additionally, Clements and Serama (2007); and Ginsburg, Cannon, Eisenband and Pappas (2006) found that young children can develop ideas about size, shapes, space, and patterns from the moment of birth until they are five years old. This acquired knowledge sets the stage for learning more complex math skills (Osana et al., 2010). According to Shaklee et al. (2008) children who attend preschool and acquire mathematics knowledge show better performance throughout their formal education.

Similarly, scholars found that early exposure to science education has led preschoolers to feel comfortable while getting education in later stages of life (Beering, 2009). Furthermore, a finding from the National Research Council (2005) suggests that high-quality science learning experiences in early development pay off with increased long-term achievement and student engagement regarding science. Despite the increased interest in teaching science to preschoolers, evaluation and research limited appropriated instrumentation. Hence, the authors of the recent National Research Council (NRC) report on assessment in early childhood (Snow & Van Hemel, 2008) added that science assessments could not be included in their discussion because there "simply was not a basis, in theory, research, or practice to include… science, despite [its] obvious importance" (p. 59).

2.2.3 Pre-schools in Europe and Turkey

Childhood is considered to be the most crucial stage where education affects child development; the European Union desires all children to get a high quality of education and care. Hence, in European Union countries 93% of children attend early childhood education before primary school. Moreover, one or two years of preschool education is compulsory in some European countries such as Bulgaria, Greece, Cyprus, Latvia, Luxemburg, Hungary, Austria, Poland, and Switzerland as well as in the Czech

Republic and Liechtenstein. All European countries impose learning objectives for older children including personal, affective, social development as well as linguistic and communicative skills. In some European countries, the requirements to attend primary school are maturity and linguistic skills. Children who do not meet these requirements may not be permitted to start primary school even though they are at the appropriate age (Eurydice & Eurostat, 2014).

In Turkey, preschools have become a hot topic in the education system (Göksoy, 2017). Therefore, the aims and tasks of preschools were determined in accordance with law no. 1739 in National Education Fundamental Law (2015). According to this law, the educational aim of preschools is to provide children with the environment to enhance physical, logical and emotional development, and to prepare them for primary education (The National Education, 2015). However, a preschool in is not considered as compulsory in most of the countries (Eurydice & Eurostat, 2014). Hence, according to PISA results, students who attend preschool educational programs statistically perform better than those who do not. This shows that preschool education maintains its effect prominently and comprehensively (Ministry of National Education, 2004).

2.3 Importance of Creating CT Skills at Early Ages

Our changing world requires students and our future nations to work harder in order to build the capacity of their knowledge and higher order thinking skills (BenChaim, Ron & Zoller, 2000; Zoller, 1993, 1999). This challenge requires the development of students' capacities of CT skills starting at an early age (Ennis, 1989; Zoller, Ben-Chaim, Ron, Pentimalli & Borsese, 2000). According to Adler (1991), developing CT skills should be encouraged at a young age because they contribute to raising the IQ of the child. Additionally, when children learn how to analyze, argue, test hypotheses, and distinguish between evidence and the interpretation of evidence, this leads them to solve problems better in real life (Zohar & Dori, 2003).

CT skills are essential for the analysis of unfamiliar situations, problem-solving and decision-making capabilities (Ennis, 1989; Zoller, Ben-Chaim, Ron, Pentimalli & Borsese, 2000). Therefore, one of the major components of recent reforms in education worldwide is to move from traditional teaching and lower order cognitive skills to higher-order cognitive skills (Leou, Abder, Riordan & Zoller, 2006; Zoller, 1993, 1999). However, CT has been given much discussion but less attention. Consequently, children who graduate from preschool lack CT skills that are necessary to succeed in their higher education or workplace (Smith & Szymanski, 2013). CT has been ignored for many reasons, mainly the focus was to have a better score in international exams neglecting other necessary skills (Choy & Cheah, 2009). In addition to this, there has been no integration of CT skills into the curriculum apart from the fact that few teachers train their students how to think critically (Wagner, 2014). Therefore, the research suggests that more in-depth focus on enhancing CT skills for preschoolers can enhance academic rigor and increase scores on standardized assessment (VanTassel-Baska, Bracken, Feng & Brown, 2009; McCollister & Sayler, 2010; Snodgrass, 2011; Tsai, Chen, Chang & Chang, 2013).

2.3.1 Strategies that enhance CT skills for a preschooler

Students' CT can be improved by utilizing activities that boost their thinking skills, thus students are better able to understand why something has occurred as opposed to just understanding what has occurred (Tsai et al., 2013). CT can be infused in a lesson plan throughout all disciplines which can be done by utilizing in-depth questioning and analysis of both data and source (McCollister & Sayler, 2010). Additionally, preschoolers' CT can be enhanced by teaching the following four disciplines; math, engineering, science and technology, which are related to STEM education, and this will lead to a better performance and improvement in communication and thinking skills among students (Kennedy& Odell, 2014).

Despite the importance of CT, it is rarely addressed in schools (Kasten 2012). Knowing that early childhood educators can do much to foster CT skills for children, the element of these CT components become apparent during the preparation stage of cognitive development, as theorized by Jean Piaget (1962). Therefore, integrating strategies that promote CT skills in the curricula of early childhood classrooms is essential for providing children with opportunities to learn these skills (Gerde, Schachter, & Wasik, 2013). Such strategies include

- Pause and wait: give child ample time to think, attempt a test or generate a response.
- Provide an opportunity to play: give child free time to play so he/she can discover cause and effect,
- Do not intervene immediately: give time to the child to discover before intervening and stepping in.
- Ask open-ended questions: ask different questions which will enhance the child's CT skills.
- Help children develop hypotheses: try asking the child, "If we do this, what do you think will happen?" or "Let us predict what we think will happen next."
- Encourage CT in new and different ways: encourage the child to find different ways of solving a particular task.

Researchers suggest that CT skills are best developed when CT instruction is more aligned with the more generic assessments of CT, which results in better performance (Marin & Halpern, 2011). Moreover, CT skills can be improved by using some strategies and the most important ones are questioning and problem-based learning. In questioning, the class teacher forms questions ranging from factual recall to divergent questioning, students make more claims and support those claims with substantial evidence as well as refuting the aforesaid claims based on evidence (Martin & Hand, 2009). In problem based learning, efficient problem solving is among the most critical skills to learn (Jonassen, 1997). According to Şendağ and Odabaşı (2009) The PBL approach involves working through the following process with a set of ill-structured problems: introducing the problem, forming groups, brainstorming on prior knowledge and opinions regarding the problem, identifying the needed information to solve the problem, making a plan, Executing the plan to solve the problem, and evaluating team performance.

2.4 Recent research

There is relatively insufficient literature that explores CT among preschool children. Two case studies have been carried out to prove the effectiveness of two methods: Philosophy for children and the use of picture books to increase and motivate CT.

A study was conducted on preschool children, with the use of philosophical dialogue to stimulate children's CT. "Philosophy for Children (P4C) which is also known as "Philosophy with children" (PwC) is a technique first introduced by American philosopher Matthew Lipman (Karadag & Demirtas, 2018). The study aimed at answering three main questions: (1) What are the effects of "Philosophy for Children" on the CT of the students involved in the study? (2) Does this effect vary from state or private schools attended by the students? and (3) What do the children participating in this experiment think of the program being tested? In their sample of 30 preschool students ranging from five to six-year-olds, it was seen that the CT of children who participated in the study was positively affected by the "Philosophy for Children" curriculum. The teachers observing the students stated that after the program, they noticed a development in the way the children express and defend their views and opinions, also the children generally conveyed a positive opinion about the curriculum (Karadag & Demirtas, 2018). Although both showed a noticeable improvement, children from the private school displayed higher performance than those of the state school.

A qualitative case study (Lawi, 2006) on the use of picture books to stimulate a child's CT was carried out involving four teachers and 22 preschoolers aged between 5 and 6. The sample was divided into two classes in two different schools. After the case was conducted and the teachers were interviewed, it was found out that CT can be nurtured starting at a very young age. Children should be able to understand the messages being delivered in picture books and make reasonable conclusions. They should also be open to listening to what others have to say and share their ideas. It is apparent that picture books are flexible teaching tools that offer knowledge and can be connected to the children's lives. The students presented a noticeable growth in the ability to perform critical analysis. They were able to decipher the "code of written and visual texts" and proved their capability to introduce what they had already known and previously experienced in order to give meaning to what they had been taught. The responses provided by the children were compared to the “Four Resources Model” by Luke and FreeBody (1990) to offer a guideline on how to understand the development of CT in children. This study shows the potential of using picture books to stimulate the CT of young children while taking into consideration that the children should be willing to get involved in social interactions and the importance of the questioning technique used by the teacher in addition to wisely selecting the picture book to best relate to the children’s interests.

Abrami et al. (2008) conducted a meta-analysis of 117 studies on critical-thinking interventions mainly targeting preschool children but also including students of higher education as well as adult learners outside of school settings. The average effect size of these interventions was 0.341 although the effect sizes across studies were significantly heterogeneous. Follow-up analyses indicated that effect sizes were significantly larger for the preschool student’s division of the study compared to the effect sizes related to the undergraduate division. Also, mixed instructional approaches, in which CT skills are taught as a stand-alone topic or module within the discipline- or subject-specific courses, were the most effective, whereas immersion approaches were the least effective. Moreover, interventions were more effective when instructors received extensive training to teach CT and when frequent classroom observations of critical-thinking teaching practice were conducted. Finally, results concluded that interventions employing collaborative learning approaches exhibited a slight advantage over those that did not use group learning. The study plays a very important role in the advancement of techniques used to improve CT with preschool children.

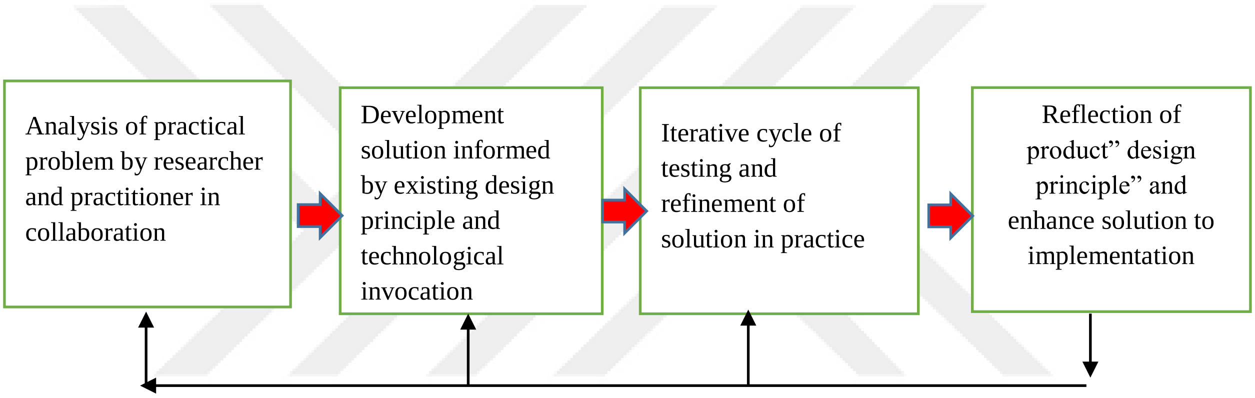
Chapter 3
Methodology

This section denotes the steps that were followed to design CT activities for preschool children. The subsections were presented by considering each stage of the ADDIE instruction model.

3.1 Research Design

In this study, Developmental Research (DR) and its stages (Richey, Klein, & Nelson, 2004) were followed to design and evaluate the activities to enhance CT skills for preschool children since DR establishes a new procedure, some techniques, and tools based upon a methodical analysis of specific cases. Development research is a type of research methodology used by researchers that involve interventions to problems. Those interventions are put to use so as to test how well they work (Amiel & Reeves, 2008). According to Davis (2013), DR is a set of components that are connected to achieve a specified outcome or goal. It is an essential methodology for understanding how, when, and why educational innovations work in practice (Design-Based Research Collective, 2003). Moreover, it helps us understand the relationships between educational theory, designed artifact, and practice (Anderson & Shattuck, 2012). It addresses complex problems in real context by integrating the known hypothetical design principle with technological advance to extract solutions to these complex problems (Reeves, 2006).

Hence, designing CT activities through DR further demonstrates the advantages of using instructional design principles. In DR the theory and practice are iterative, participative and situated; thus, in other words, design and research activities cannot be conducted separately (Wang & Hannafin, 2005). Figure 1 represents the process of DR aligned with the stated study. The first cycle represents the practitioners who are seen as valuable partners in establishing research question and defining the problem. Afterwards, a design for the learning environment is proposed, and then the development of the design will undergo series of testing, as a result, as data are tested and examined, a new design is created and implemented.



Refinement of problem, solution, method and design principle

Figure 1. Developmental Research Model.

Note: Adapted from Design research from a technology perspective by Reeves, T. C. (2006). In J. V. d. Akker, K. Gravemeijer, S. McKenney & N. Nieveen (Eds.), *Educational design research*
(pp. 52-66). UK: Routledge.

In this study, the ADDIE instructional design model was adopted due to its simplicity since it provides a structured linear approach to instructional system design (ISD) (Bahl & Alam, 2012). The ADDIE model is usually used by the instructional designers and training developers, and it consists of five phases; Analysis, Design, Development, Implementation, and Evaluation (Davis, 2013). In analysis phase, the problem is clarified, goals and objectives are set, and learners' knowledge and skills are identified. Design Phase deals with a learning objective and assessment of the instrument, lesson planning, and subject matter analysis. Development phase is where the teaching resources are developed, and the project is reviewed and revised according to the feedback obtained. In implementation phase, the course is delivered to the learners, and the training covers the course curriculum, learning outcomes, a method of delivery, and testing procedures. Evaluation phase consists of two parts, formative and summative. The formative evaluation is presented at each stage of the ADDIE process, while the Summative evaluation is presented at the end of the course.

3.2 Participants

In DR, the participants of the study vary according to the stages of instructional design. Table 3 summarizes participant involvement at each stage of the instructional design. In this table, students' names were referred to by symbols due to confidentiality.

Table 3

Participant by Stage of Instructional Design (ADDIE Model)

	Analysis	Design	Development	Implementation	Evaluation
STU1	X				X
STU2	X				X
STU3	X				X
STU4	X				X
STU5	X				X
STU6	X				X
STU7	X				X
STU8	X				X
STU9	X				X
STU10	X				X
STU11	X				X
STU12	X				X
STU13	X				X

STU14	X				X
STU15	X				X
SME (*n* = 1)	X	X			X
Instructional Designer (*n* = 1)	X	X	X	X	X
Teacher assistant (*n* = 2)				X	X
Parent (*n* = 15)	X				X
Evaluation Expert (*n* = 1)			X	X	X
ECE expert (*n* = 1)	X	X		X	X
Researcher (*n* = 1)	X	X	X	X	X

1. Analysis stage: preschool children, a subject-matter expert, parents, researcher and ECE expert.
2. Design Stage: subject-matter expert, instructional designer, researcher, and ECE expert, evaluation expert
3. Development Stage: subject-matter expert, two instructional designers, ECE expert, and researcher.
4. Implementation stage: 15 young learners, instructional designer, a subject-matter expert, researcher, assistants to the teachers, and ECE expert.
5. Evaluation stage: a subject-matter expert and two teacher assistants, researcher, ECE expert, and fifteen young learners.

Variety of experts took part at each stage of the instructions. The ECE expert, subject matter expert, instruction designer, 15 parents,15 learners and the researcher were involved during the needs analysis stage. The ECE expert played a significant role in the need analysis stage of the program, and her participation was very valuable for the study due to her knowledge of the background and levels of the students that were participating in the study. She is around 55 years old with 30 years of experience in early child education and has dedicated her life to working and exploring how children behave and think. The ECE expert is the owner and founder of three preschools in Istanbul that provide a unique and revolutionary program which aim at teaching babies' skills and concepts that should be learnt at an early age through play and songs. The subject matter expert was also involved in the need analysis stage of designing CT activities. He is the founder of a technology company which produces high-tech materials, and he has an educational TV program for tech recycle and other scientific experiments. Although the subject matter expert does not have an experience of teaching preschool students, he has 15 years of experience in teaching adult students and has a passion of teaching and designing activities for this age group. Furthermore, the instructional designer has four years of experience in producing educational materials and in designing lessons. He has participated in different workshops and designed various lessons related to STEM education for young learners. Also, he translated scratch coding books into Turkish and designed lesson plans for teaching from scratch for young learners.

In the "learner analysis" stage, fifteen young learners who were represented by a code "STU" aged between 3-6 participated in this research. All of the children who participated in the research had a good command of English language since they were enrolled in an English preschool, all of the learners come from wealthy family and they are exposed to technology and new inventions. At this stage, learners' features and context analysis were analyzed by the ECE expert, the parents, and the researcher, as the ECE expert knows each child very well because they attend her school. Moreover, the involvement of the parents in the analysis stage was essential as they were asked to analyze their children's learning preferences since the participants are very young and might not be able to analyze their preferences alone. In this study, demographic information for young learners are given in table 4.

Table 4

Learners Demographic Information

Code	Age	Gender	Learning Preference
STU1	4	Male	Technology & Robotic
STU2	4	Male	Technology & Robotic
STU3	5	Male	Technology & Robotic
STU4	4	Male	Technology & Robotic
STU5	5	Female	ART & Music

STU6	6	Male	ART, Technology, Math
STU7	5	Female	Science
STU8	4	Female	ART& Science
STU9	6	Female	ART & Technology
STU10	3	Male	Technology & Robotic
STU11	4	Female	Math & Science
STU12	5	Male	Technology & Robotic
STU13	6	Male	Technology & Robotic
STU14	3	Male	Technology & Robotic
STU15	3	Male	Technology & Robotic

The researcher, who has five years of experience in working with preschoolers, participated in all the stage of instruction. The researcher has conducted different projects related to STEM education and has been working with students of different ages. In addition to the experiences mentioned above, the researcher also developed an assessment rubric for the participant and an observation form.

Two assistants to teacher participated during the implementation phase, which is considered a field test of the activities. One of them is 25 years old and has a bachelor's degree in computer science, and three years of experience working in a company that produces educational material, while the other is 27 years old and has a bachelor degree in early childhood education, and she is currently doing her internship with a Turkish preschool in Istanbul.

In the "evaluation phase," the ECE expert, SME, and researcher evaluated the designed activities by conducting small group formative evaluation with the learners. The activities were also validated by an expert in education and technology design, which has over 20 years of experience teaching software engineering and database courses. He evaluated the flow of the lesson plan and enriched his feedback from expert opinion in the childhood education field.

In this study, some prerequisite skills were required from the participants. Learners were required to know Basic English, and the ECE expert evaluated the English level of learners since she had worked with them before. Young learners were required to perform basic motor skills activities, such as cutting, folding papers, and painting.

3.3 Data Collection

This section represents the data source, data collection tools and data collection procedure that were used at each stage of the instruction model, with a different group of participants. Both qualitative and quantitative methods were used to answer research questions. Various instruments were used to increase validity and credibility of the research, as Fraenkel, Wallen, and Hyun (2011) indicated. Nevertheless, Golafshani (2003) claimed that both the terms validity and reliability could mislead while conducting qualitative research as they both rely on the conception of the researcher and how he conducted the study. For this reason, Golafshani (2003) suggests taking into consideration both the quality of information, and the results obtained. Table 5 shows the research questions mapped with data sources.

Table 5

Research Questions Mapped With the Data Source

Research Questions	Interview with ECE Expert	Interview with an instructional designer	video recording	Survey learners' skills	Learners perception toward instructional strategy	Learners perception toward instructional	Expert validation form
What are the needs and instructional goals of designing CT activities for preschool children?	X	X					
What are the characteristics of preschool children participating in instructional activities to foster their CT?				X			
What are the CT assessment and evaluation criteria for preschool children?							
How are the instructional activities to foster CT of preschool children developed?		X					
How are the Objectives of the activities aligned with CT skills and sub-skills to foster CT skills for preschoolers?	X	X					
How are the instructional activities to foster		X	X				

the CT of preschool children implemented?					
What are the outcomes of the implementation of the instructional activities to foster CT of preschool children?	X				
What are the perceptions of preschool children toward the instructional activities to foster their CT?	X		X	X	
How are the instructional activities to foster CT of preschool children validated?	X	X			X

3.3.1 Data collection tools and procedures

In this study, seven different data collection tools were used, 1) Interview forms, 2) Learners analysis form, 3) Progress report, 4) Observation form,5) Expert validation form, 6) Learners perception toward instructional strategy, 7) Learners perception toward instructional materials. Hence, triangulation was achieved through the utilization of different tools (Fraenkel, Wallen, & Hyun, 2011). Table 6 represents the data instrument at each stage of the instruction.

Table 6

Data Instrument Across by Stage of Instructional Design

Stages	Interview	Learner analysis form	Progress Report data	Observation form	Expert validation form	Learners perception toward instructions	Learners perception toward selected material	Video analysis
Analysis								
Need assessment	X							
Learner analysis		X						
Design	X	X						
Development	X	X						
Implementation	X	X						
Evaluation			X	X	X	X	X	X

3.3.1.1 Interview Forms

This study utilized semi-structured interviews to attain data. Semi-structured interview is a technique which generates rich data, whereby participants involved in a clear description of their thought processes (Newton, 2012). A semi-structured interview entails a set guide of questions created by the interviewer; however, this set of questions follows a “tropical trajectory” which enables the researcher to stray away from the guide if necessary (DiCicco-Bloom & Crabtree, 2006). Moreover, in qualitative research, interview techniques are considered useful for obtaining the story or problem behind a participant’s experience. Interviews lead to in-depth information around a certain topic (McNamara,1999).

The ECE expert interview form consisted of six semi-structured open-ended questions with the aims of identifying the necessity to design activities for young learners. This form was developed by considering the related literature and having an expert opinion by the researcher. The interview took about one hour, no problem was encountered during the interview, and the researcher gathered data which is related to the main topic. During the interview, the notes were taken, later summarized, reviewed, and categorized. Below are the interview questions that were prepared with the ECE expert.

1- Why do you think this program is essential for young learners?
2- What type of CT activities do you implement in your school?
3- Which age range can we teach in the same session? Why?
4- Do you think a parent would agree to their children using a tablet and technological device?
5- Do you assess your students’ CT skills? If yes what assessment criteria do you follow to assess the children’s skills?
6- Do you want this program to become a part of your school curriculum in the future?

The SME and instructional designer interview form consisted of four open-ended questions with the aims of understanding how CT is being taught in schools, and the activities that should be designed to enhance CT skills for young learners. The questions aimed to understand how the SME and instructional designer are willing to design and produce materials that match preschoolers' capabilities as well. This form was also developed by considering the related literature and having an expert opinion by the ECE expert. The interview took about two hours, in the first hour the researcher interviewed the SME, during the interview notes were taken, later summarized and categorized according to themes, however in the second hour The researcher conducted an interview with the instructional designer, concerning how the resources will be produced, Notes were taken, summarized and analyzed according to important topics, the data that were obtained from the instructional designer and the SME were combined and categorized into important theme (See Appendix G) for more details.

1- What are the essential features of teaching CT activities in the classroom?
2- Why do you think embedding CT skills in the preschool curriculum remains a rare practice in classrooms? What is/are the main obstacle(s) to make this leap?
3- Why do you think that teaching technology in preschool is still not applicable in Turkey? Moreover, how do you imagine a classroom in the future?
4- What are the main topics that should be taught to preschoolers, and would a child at this age need constant assistance?

3.3.1.2 Learners analysis skills form

For data transferability, the researcher explained the characteristics of the participants before the study as well as the need for assessment. Therefore, a form was developed by the researcher in order to obtain information about learner's demographic information, "capabilities, perception, skills, and learning preferences". The form included five items for demographic features, five items for CT skill capabilities, four items for learning preferences, perceptions towards delivery systems, motivation and group characteristics, and four items for technology used at home. The form was presented to the ECE expert and the SME who approved it and recommended no change. The form was completed by the SME and instructional designer after their visit to the school. Hence, the form was sent to the ECE expert as well to be filled according to CT criteria related to the child's skills. A discussion was held with the subject-matter expert, instructional designer and the ECE expert about entry behaviors of the learners.

3.3.1.3 Observation form and video analysis

Participant Observation form. Observation is considered as a gathering data technique by which the researcher is able to recognize and note subjects during the session (Musante & DeWalt, 2010). It is important that the researcher should have full knowledge of the activities and the lesson objectives which help gathering fruitful information. Accordingly, the observation form was designed by the researcher according to preschool assessment criteria that were stated by different scholars (Neuman, Copple, and Bredekamp, 2000) and highly recognized educational organizations such as NAEYC (1987), and American Educational Association (1999). The observation form was adopted from Pearson 21, which is an international learning company, which provided different expertise in educational courseware and assessment, powered by technology for CT assessment for preschoolers (Ventura, Lai, & DiCerbo, 2017). The ECE expert validated the observation form and necessary changes were made according to her feedback, the changed that were made focused more on child development according to communication skills. The observation was conducted on a weekly basis; the researcher focused on what skills learners are acquiring while building the projects (See Appendix D). Video analysis was used in case any missing data, therefore researcher will be able to go back to the recorded session and add his notes to the learners' report.

3.1.1.4 Progress Report Form

This progress report was developed by the researcher, the report entails five key CT skills, including subskills adopted from Facione's (1990). This report was written after carefully observing students; with a particular focus on their CT. This report data involves reporting students' progress to note their achievement levels. Figure 2 represent the learner's skills achievement report.

During each session, the researcher observed the learners, by focusing on their achievements using a certain criterion (See Appendix E Preschool Assessment Rubric).

Furthermore, opinions were gathered from the SME and ECE learners, in order to finalize each and every student's report, which ensures the absence of biased data.

The progress reports were filled out during the first and third week and the second progress report was filled out between the fourth and seventh week. The final third progress report was filled out right at the end, when the sessions were over. Here as well, each subset achieved, received one point over the total amount of subsets within each of the five sets.

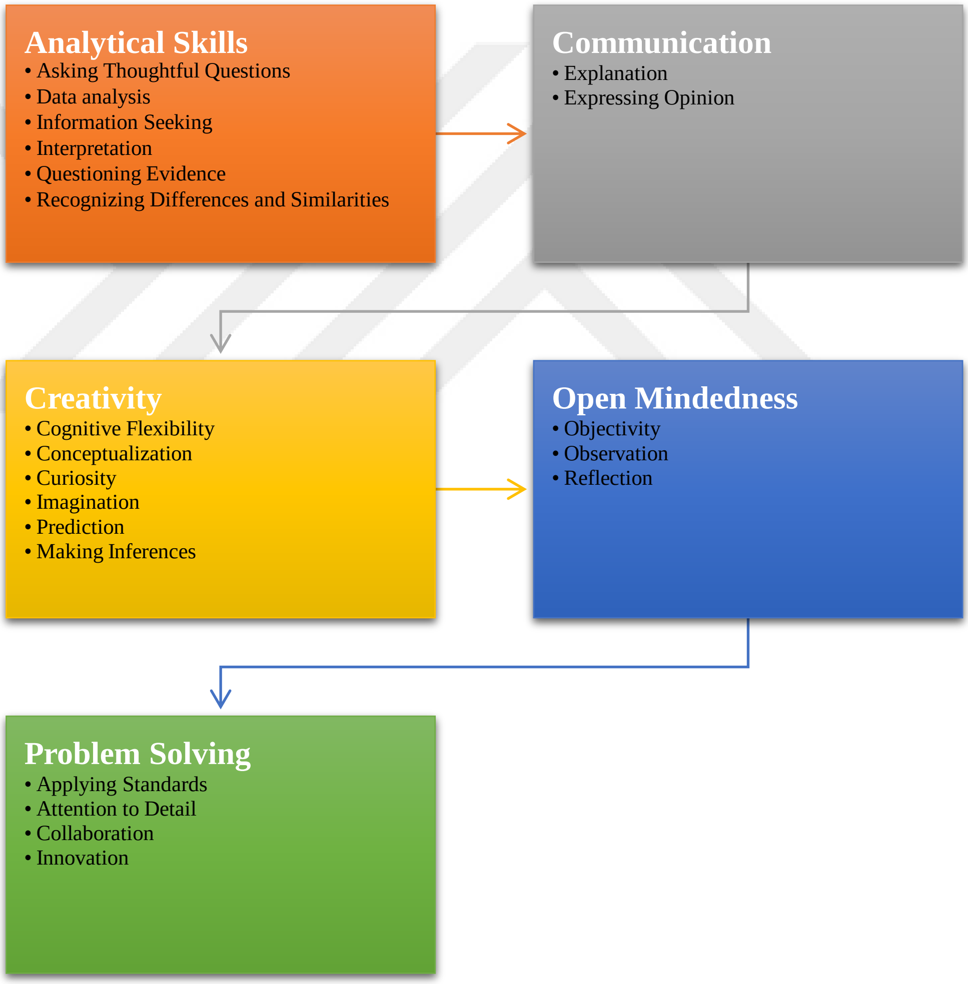


Figure 2. *Learners Skills Progress Report*

3.3.1.5 Expert validation form

The expert validation form was developed by the researcher to validate the activities designed in terms of instructional strategy and the materials used. The expert validation form was adopted from Dick, Carey and Carey (2005) and includes six items to observe during the session with a scale ranging from, 1-5 poor/good respectively; the introduction, the objective of the lesson, the lesson flow, the materials used, the technology used, and the class arrangement. During each session, the ECE expert wrote notes, which were then gathered and summarized. The summarized notes were then presented to the SME and instructional designer, for further enhancement and adjustments. The expert validation form aided with the improvement of quality teaching, detailed instructions, and the materials produced to meet the learner's needs.

3.3.1.6 Learners feedback form (Instructional strategy/developed material)

The learner’s perception form is developed by the researcher, to evaluate the activities in terms of learner’s perception toward the designed materials and instructional lead instructions. The SME and instructional designer will adjust the activities and the instructional strategy accordingly after reviewing the learner’s perception. The learner’s perception form is adopted from (Dick, Carey, & Carey, 2005). The form included certain criteria related to the lesson flow, designed material, instructions, and the learner’s opinion about the instructor. Additionally, the form consists of scale range from 1-4: Poor-good. Hence the learner’s estimation was gathered by conducting one to one formative evaluation with the learners and asking them different questions; these questioners are adopted from BIE buck institute for education (Gültekin, 2005). Additionally, BIE Questionnaire has a scale range from 1-3: Still Learning-Almost Always See Appendix H for a CT questionnaire). This form was completed by the researcher during the last session of the workshop.

3.3.1.7 Evaluation (Designing and conducting the formative evaluation).

A formative evaluation was carried out to assess the solidity of the designed CT activities. The subject matter expert (SME=1), E Expert, instructional designer, researcher, and learners (STU= 15) were present during the evaluation of the designed program. In order for the evaluation to be completed, three dimensions need to be considered. These are as follows; 1) The learners' perception towards the designed material, 2) Formative evaluation of the selected material and instructor lead instruction, 3) Learners' development in terms of their skills

Both one to one and small group formative evaluation was conducted in this study to examine the effectiveness of the designed material (Kirshner, Salomon, & Chin,2003). According to Sharan and Sharan (1976, p. 10), a small group formative evaluation has the advantages of initiating focused, equal, dynamic, interactive, and quality discussions. Moreover, assessment plays an important role in educational accountability since it assesses the outcomes of students' learning. Hence, educators should be able to assess how students are managing the learning process as well as what they are achieving (Ryan, 2005).

Moreover, a one to one formative evaluation was conducted to obtain the learners perception toward the instructors lead instruction and the designed material. This was conducted in the final session of the workshop; the researcher collected data, by asking the learners design related questions, including how they felt the lesson was delivered by the instructor. Gathering feedback can provide information about the existing gap between the actual level and desired level of performance (Rushton, 2005). Formative evaluation of the selected material and the instructor-led instructions were conducted by the researcher and reviewed by the ECE expert. The learner's feedback and notes were given to the instructional designer and the SME who are responsible for adjusting the instructional strategy and the resources produced; based on the feedback provided. See figure 3 which represents one of the learners during a one to one evaluation.

A small group formative evaluation was conducted to monitor the learners' gained skills during the 10-week-period. Data collection observations and progress reports were used to complete the information. A small group evaluation was conducted after every session and learner's achievement were reported every three weeks. During the session, the researcher observes each learner by working directly with him/her to gather the needed information. Information is gathered by closely viewing the CT skills criteria, for example, what children are capable of and how they can problem solve. (See appendix D for observation rubric).

Figure 3. *Learner During the Formative Evaluation*

3.4 Data analysis

Qualitative data were collected from the interviews, observations, learner analyses, and, expert validation form, while quantitative data was collected from progress report, learner's skills analysis, Learners perception toward selected materials, and learner's perception toward instructional strategy

Qualitative data were analyzed using descriptive analysis method, which is one of the methods of qualitative analysis that mainly aims to present obtained findings to the reader in a summarized and interpreted manner (Yıldırım & Şimşek, 2011). The descriptive analysis was designed in four stages. First, the researcher created a framework of data based on the research question, then the researcher categorized the data into a theme so that the data gathered was placed in a meaningful and logical manner. The researcher then organized and defined the data, and at the final stage, the researcher explained and interpreted the findings (Bogdan and Biklen, 1992). The researcher applied the thematic content analysis of the collected data and identified the main themes accordingly. Hence, the analysis of results was translated into tables considering the theme.

Quantitative data were analyzed from the general summary about learners' skills. Hence, while describing learners' preference and demographic information by using SPSS 20 to obtain the mean and standard deviation about each skill for every learner, the learners' entry skills were converted into numbers, since each skills have different number of subskills, the researcher equalized the denominator of the result and converted the number into real number, these result were then calculated and analyzed using SPSS. This aimed to capture the learner's progress for a duration of ten sessions. Another quantitative data was analyzed by obtaining the learners perception toward the instructions, the rubric entailed scale out of four, the researcher completed the form by observing the learners and asking them question related to CT (See Appendix H) to finalize the result. Additionally, the expert validation form was also obtained by using a rubric which consist of a scale out of 5, and the result was based upon the expert validation on the designed product.

3.6 Limitations

This study has certain limitations which should be taken into consideration. One of the limitations is that the number of participants was very small, so the findings cannot be generalized for the rest of the preschoolers.

The study is limited to one ECE expert, one subject matter expert, and one instructional designer. Lastly, a limitation was present regarding participants' socioeconomic backgrounds; that is, all the participants were from a wealthy family, which might have enabled them to be exposed to technology and sophisticated games and to attend the best schools in Turkey. This raises the possibility that these children's upbringing helped enhance their chances of scoring better at this study than other "not so privileged" children. Perhaps in the future, this study can be recreated to include students from diverse backgrounds and experiences in order to better assess the claim on a larger scale. The only challenge is acquiring appropriate funding as classroom sessions required high-end resources that proved to be costly.

Chapter 4
Result

In this section, the findings of the study are given in details under each subheading according to each stage of the instructional design.

4.1 Need assessment to Identify the Goal

At the stage of need analysis, the study was carried out to determine the need for building CT activities for preschoolers. Data were gathered from different parties (SME, instructional designer, and ECE expert) by obtaining their opinions, and interview results were analyzed descriptively, and categorized according to different themes. The emerged themes were as follows; (1) the importance of teaching 21century skills, (2) the importance of acquiring CT skills at an early age, (3) lack of teaching CT skills at preschools, (4) the importance of using technology to teach CT skills, and (5) the need to design activities to enhance CT skills. Table 7 shows the findings obtained from interviews and related literature reviews. It was seen from the interview notes that most of the preschools in Turkey lack CT activities using high technology and that schools do not embed CT skills into their curriculum. (See Appendix G for interview details).

Table 7

Emerged Themes Across by The Data Sources

	Interview with ECE expert	Interview with SME	Interview with instructional designer
The importance of teaching 21^{st}-century skills	X	X	
The importance of acquiring CT skills at an early age	X	X	
Lack of teaching CT skills at preschool	X	X	
Designing activities to enhance CT skills		X	X
Using technology to teach CT skills		X	X

4.1.1 The importance of teaching 21-century skills.

The results of this theme were identified from the analysis of the data obtained from the interview with the ECE expert and the SME. During the interview with the subject matter expert about acquiring 21st-century skills, the results implied that acquiring CT skills leads students to gain analytical thinking when the expert indicates that: "*It is essential to guide students of this generation to acquire 21th century skills so that students will be able to perform analytic thinking.*" Moreover, the SME also assured that a person who gains 21st-century skills would be able to perform better in life when he said that *"students need to be able to demonstrate higher-order thinking skills and apply their learning. Since many of the challenges that our children will face in the 21st century do not have clearly defined answers."* The ECE expert also implied that gaining 21st-century skills will lead to better performance in education and life, and it should be taught at an early stage when she said that "*21st-century skills should be acquired since it affects student performance in primary and secondary school.*"

4.1.2 The importance of acquiring CT skills at an early age.

The results of this theme were identified from the analysis of the data obtained from the interview with the ECE expert and the SME. The ECE expert emphasized that CT skills should be taught at an early age. She also imposed that no preschool in Turkey is giving attention to teaching such skills of early learners, "*Preschools in Turkey are not teaching and assessing CT skills for preschools for different reasons, 1) lack of expertise in this domain, and 2) the high cost to build CT activities for young learners*". Moreover, the ECE expert indicated that it is essential to teach CT skills at an early age by saying *"When you teach children CT skills they will be able to find the information for themselves; to evaluate the consequences of that information, and they will be able to utilize that information to solve any problem at hand."* In addition, when the SME was asked about which CT skills is important for young learners, he indicated that "*There are no specific skills that a child must gain, each child can master different skills."*

4.1.3 Lack of teaching CT skills at preschool.

This theme emerged from the data obtained from the interview with the ECE expert, and SME. The ECE expert implied that most preschoolers lack teaching CT skills, and this is due to lack of expertise, and followed by saying that focusing more on different skills will prepare the students to primary and secondary school. When she was asked about more details on CT activities in a preschool environment, the ECE expert responded; "*Normal activities such as toys, that teach multitasking, art, and music, are being taught to young learners, but there is no approved curriculum on activities that enhance CT skills for young learns and assessing what skills they had gained later on.*" Moreover, the SME opinion emphasized that there is a lack of CT activities in preschool by saying: "*Preschools still lack well-designed activities, STEM education, and robotic education, which will lead to better thinking skills." Similarly,* the ECE expert believes that communication and open-mindedness skills are very important for children at this age, since it will encourage each child to be unique, and educators should be aware of each child's skills by observing them during class: *"According to my expertise with children, communication and open mindedness skills are the most important skills for children and our mission as an educator is to observe them and guide them for better performance."*

4.1.4 The importance of using technology to teach CT skills.

Interviews with the instructional designer and SME served to enquire about the ability to design new activities for preschoolers, and the possibilities to incorporate technology. The SME assured that technology is very important since we are in the 21^{st} century, and even preschoolers must be introduced to new technology when he said; "*Since we are in 21st-century activities must be taught using the latest technology. Unfortunately, schools and education system lack expertise in this field. Hence this will result in lack of activities that teach CT skills using technology.*" Moreover, the instructional design implied technology-motivated young learners when he said: *"Technology-motivated learners, especially young children who are always curious to learn new things."*

4.1.5 Designing new CT skills activities for preschoolers.

Throughout the interviews with the SME about the competences of designing activities that enhance CT skills for preschoolers, it was found that designing such activities needs deep analysis on learners' skills and their competencies. Therefore, activities are designed to match early learner's skills and cognitive abilities. Moreover, the SME accentuated that designing activities to match different age levels will not be a simple task when he said; "*activities should be designed to capture the attention and skills for all age group at the same time. Therefore, different projects with a range in difficulties will be designed, and the task will be assigned to the older group."* Moreover, the SME mentioned that the designed activities will be brand new activities that will demonstrate different subjects, which are relate to Science, Math, Engineering, and Technology. He also emphasized that "*Every workshop is a prerequisite to the next. Therefore, children's skills will be enhanced by building the different project, according to their skills and age range, a layered curriculum will be used."*

The SME also explained how the lesson will be connected by giving an example of how the animation lesson will be taught. He explained that "*to teach animation, children have to learn the history of how animation was formed. Therefore, the lesson flow will be designed as follows*: *(1) Teaching the concept of SCANIMATION Paper, (2) Introducing Praxinoscope, (3) Designing a Book page flip and (4) 4) Using Flip Anim application to design their animation.*"

4.2 Analyzing Learners and Context

In the learner analysis stage of instructional design, the result of the form that was filled by the ECE expert, the parent, the researcher and the SME was analyzed and summarized. Table 8 shows the summary of results of the learners' entry skills according to CT criteria. The results showed that there was a deficit in some areas of CT, with greater inter-group differences amongst some of these groups. Analytical thinking and communication score both had a mean of 2.6 for all 15 preschoolers. However, the standard deviation was larger (*SD* = 1) for communication compared to analytical thinking (*SD* = 0.5); meaning that there was a larger discrepancy in scores on levels of communication among preschoolers compared to analytical thinking. Highest scores were attributed to creativity (*M* = 3.1), with a small SD of 0.5, meaning that the high score observed was seen among almost all preschoolers in this study, with little difference between individual scores. Open-mindedness had the lowest mean score of 2.2 with a considerable SD of 0.7; meaning that scores in this area varied significantly on the lower side of the scoring system. Problem-solving had a mean score of 2.6, similar to analysis and communication, with less variation between individual scores compared to communication (*SD* = 0.7 versus *SD* = 1, respectively), but with more variation in individual scores compared to analytical thinking skills. (*SD* = 0.7 versus *SD* = 0.5, respectively). Therefore, the new designed activities aimed to focus on open mindedness and communication skills, which will be shown in the instructional strategy and developing materials sections.

Table 8

Learners Skills Analysis According to CT

Learners	Analytical	Communication	Creativity	Open minded	Problem solving
STU1	2.00	2.00	3.00	2.00	2.00
STU2	3.00	3.00	4.00	2.00	3.00
STU3	2.00	3.00	3.00	4.00	3.00
STU4	2.00	3.00	3.00	2.00	2.00
STU5	3.00	3.00	4.00	2.00	2.00
STU6	3.00	3.00	4.00	4.00	3.00
STU7	3.00	3.00	3.00	2.00	4.00
STU8	3.00	3.00	3.00	2.00	3.00
STU9	2.00	.00	3.00	2.00	2.00
STU10	3.00	3.00	3.00	2.00	4.00
STU11	3.00	3.00	3.00	2.00	2.00
STU12	2.00	3.00	3.00	2.00	3.00
STU12	3.00	3.00	3.00	2.00	3.00
STU14	3.00	3.00	3.00	2.00	2.00
STU15	2.00	3.00	2.00	2.00	2.00

The form which was sent to the parents for them to fill out, was to question about their children's subject preferences to learn. A child learning preference report is normally sent as a report from school, which indicates which subject area each student is interested in. Learning preference is a very essential part in learners' analysis, since the activities are new, and the topic will be chosen based on students' interest. Nine learners Mostly male showed interest in learning technology and robotic, and five out of fifteen learners mostly female, showed more interest in art and science.

4.3 Instructional Analysis/ Performance Objectives/Developing Assessment Instruments

In this part of the study, instructional analysis, writing the performance objectives and developing assessment instrument stages were designed by the researcher and finalized with the help of SME and ECE expert (see table 9). Hence the purpose of the design activities was teaching CT skills for young learners after completing the workshop, Figure 4, summarize the skills, sub-skills, and the learners' entry skills. Learners had to perform each activity according to bloom taxonomy hierarchy; however children were not supposed to gain all skills and sub-skills that are related to CT, the purpose was to enhance these skills by the end of the workshop for activity validation.

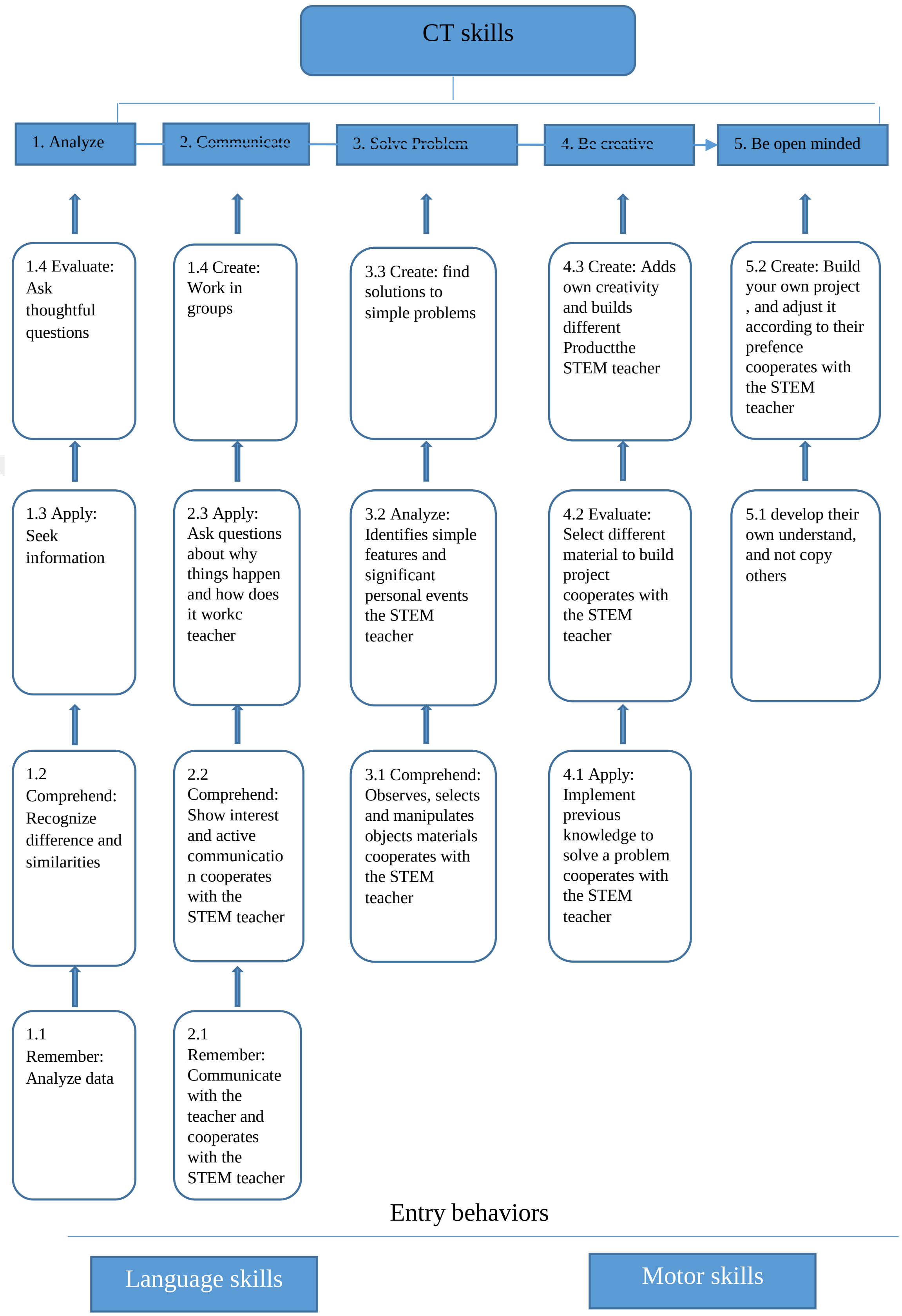


Figure 4. *Skills Analysis Chart*

Table 9

Skills Related to Outcomes

	CT Skills	Performance objective
1.1 Analytical skills	1.1 Analyze data	Given YouTube, video learners will recognize the topic that will be discussed.
	1.2 Recognize difference and similarities	Given a package of resources, learners will sort, the material and arrange them according to colors, size, and functionality.
	1.3. Seek information	Given a set of material with written instruction, learners will follow the instructions to build their product.
	1.4. Ask thoughtful questions	Given the final product, learners will ask questions related to the topic.
2. Communication skills	2.1 Communicate with the teacher	Given different resources, learners will ask the instructors questions related to the topic.
	2 2. Show interest and active communication	Given a class with different technology and resources, leaners will show interest and start communicating with their peers and the teachers.
	2.3 Ask questions about why things happen and how does it work	Given a certain product, learners will try to discuss how it can work, and how was it made etc...
	2.4 Work in groups	Given a ready product Learners will play games, work in a group, make a competition.
3. Problem-solving skills	3.1 Observes, selects and manipulates objects materials	Given a set of different resources, learners will observe the instructor, and design their own.
	3.2 Identifies simple features and significant personal events	Given different product learns will use previous knowledge to create their own.
	3.3 find solutions to simple problems	Given a product with missing piece learners will find a solution to make the final product active.
4. Creativity	4.1 Implement previous knowledge to solve a problem	Given a new product, the learner will Figure out its functionality by relating their experience with previous knowledge.
	4.2 Select different material to build project	Given a set of material, learners will ask the instructor to provide them with something different.
5. Open minded	5.1 develop their own understanding, and not copy others	Given a set of activities, learners will create their own product adding their own and unique style without copying their peers.
	5.2 Create: Build your own project and adjust it according to their preference	Given a set of instruction, learners will be expected to design a unique and different product that will not be exactly like the instructor product.

After the first schema was completed by the researcher and the SME, the ECE expert opinions were taken, and certain changes were made. Lesson strategies were adjusted to motivate the learners and push them to perform the desired skills, for analysis skills, the SME should ask certain questionnaire for the learners to allow them to participate. Moreover, for communication skills to be enhanced a little modification were made, such as forming a group, playing games, and using some behaviorism approach to encourage the learners to participate, such as gift and treats. In addition, the ECE expert found that early learners would be motivated to learn when they do unique product, and this was adjusted when the SME and instructional designer readjusted the final product, so each learner will be able to do unique product, different color, different functionality and different size. Table 9 present skills related to outcomes.

In order to be eligible to participate in the program, the children should demonstrate certain skills such as good command of English language and good motor skills such as being able to cut, fold, sort, etc. However, if some children do not acquire the above-mentioned skills but are interested to join the program, the parents should sign a consent that they allow their child to participate under the condition that a teacher assistant supports him/her during the workshop.

4.4 Developing Instructional Strategy

In this study, the SME, the instructional designer and the researcher all collaborated to design and develop CT activities. The researcher's role was to coordinate the interactions between the SME and the instructional designer. The SMEs' role was to develop the lesson plan and the instructional designer's role was to design the activities and produce resources. Resources were chosen carefully, in terms of practicality, safety and ease. Since young learners use these resources; all resources need to be adequate and age-appropriate, for example, not too small (choking hazard) and not too sharp. It was vital the researcher checked the resources and the lesson plans in order to adhere to the learners' age and needs. If for any reason, the resources were not suitable, it's the role of the instructional designer to adjust the resources accordingly. The activities were designed to enhance the learners CT skills, therefore, the objectives of the lesson were mapped with CT skills and sub-skills. Each task was carefully chosen, and the lesson plan was designed for the purpose of teaching and having fun at the same time.

Since preschoolers' attention span is very short, the instructional designer produced five projects for each lesson, where each project needed 10 minutes to be completed. The activities were divided into 10 sessions where each session was 75 minutes long, contained five projects, a game, and videos related to the topic. The activities were designed to teach Engineering skills, Math skills, Science skills, and Art, using latest technological tools such as augmented reality and virtual reality. In addition, most of the designed activities focused on improving social and open-minded skills by encouraging leaners to build their own style, and not by copying others. Table 10 summarizes the workshop topics.

Table 10

Workshop Plan Summary

A. OVERVIEW: CT activities were designed by a group of experts, the activities were designed to teach different disciplines; Science, technology, Engineering and, Mathematics. The aim of the lessons was investigating whether these activities affect preschoolers' CT skills.
A. PREREQUESITE SKILLS: Participants were accepted to attend the workshop according to their age and language level and ability to perform motor skills activities
B. LEARNING GOALS: 1. Use analytical skills: by asking question, and analyzing the data, participants will learn how to interpret information and recognize similarities and difference. 2. Use their communication skills: the participants will learn how to communicate and express their opening 3. Use their creativity skills: children will be curious by investigating new phenomena and making inferences. 4. Open minded: Participants will be able to observe and reflect their ideas and share them with others. 5. Problem solving: Participant will be able to use their logical thinking by paying attention to details.
C. MATERIAL AND TECHNOLOGY USED: 1. Computers, 2. Magnetic drawing machine, 3. Bionic arm, 4. Coding car, 5. Robots 6. I pads, 7. Mobile phones, 8. 3D printer, 9.Chocolate drawing machine
B. INSTRUCTIONAL PLAN: Session 1: Vibrating Toothbrush Session 2: Air pressure Session 3: bionic arm Session 4: Magnetic Force Session 5: Mirror and lenses Session 6: Art of drawing Session 7: 3D modeling Session 8.: virtual Reality

Session 9: Augmented Reality
Session 10. FORMATIVE EVALUATION

The ECE expert evaluated the flow of lesson plans, as well as the lesson objectives. In addition, resources and material used were also evaluated by the ECE expert by doing demonstration day before the workshop to ensure that nothing will go wrong. Moreover, scientific vocabulary that were chosen to teach certain topic were evaluated by the ECE expert to ensure that the learners are capable to understand certain terminology. Table 11 represents one of the lesson plans together with the ECE expert notes (see Appendix I for a more detailed lesson plan). The ECE expert evaluated each lesson plan with respect to the evaluation rubric adopted from (Dick, Carey, & Carey, 2005), and her comments were summarized in table 12.

Table 11

Lesson plan "Vibrating tooth brush"

CT Skills	Sub Skills	Lesson objectives	Expert comments
1.Analytical 2.Communication 4. Open-Minded 5.Problem-solving	<u>Objective 1</u> • Asking Thoughtful Questions • Data analysis • Information Seeking • Interpretation <u>Objective 2</u> • Expressing opinions and ideas • Verbal Communication <u>Objective 3,4</u> • Observation • Reflection <u>Objective 5,6</u> • Logical Reasoning • Attention to detail • Innovative	1-Students will state how toothbrush can vibrate using battery 2-Students will explain why the battery made the toothbrush to vibrate. 3-Students will demonstrate how toothbrush can move in a different direction but adjusting the battery position while communicating with each other's they can discuss which position is the best. 4-Students will differentiate between their product performance and their classmate's products performance while making a race with their toothbrush. 5-Students will test how batteries can move an object. 6-Students will design a car that works on battery.	Creativity skills did not match this lesson plan since they did not create their own product; they were given instructions and followed the instructor guide to finalize their product.

Table 12

Expert evaluation on lesson plan

Lesson Parts	Quality Rate	Expert suggestions
Introduction	4 Average	Videos, questions and answers sessions motivated learners, but could not capture three years old children, who can be distracted while watching videos. Videos could be replaced by hands-on activities.
Objectives	4 Average	All objective should enhance CT skills, some objectives were not linked to certain skills, which should be adjusted
Material quality	5 excellent	Resources were very easy and safe, colorful, and were designed to match the target objectives, and suggestion is required.
Lesson flow	4 Average	The first 30 minutes of the lesson goes smoothly, then children require assistance while building their project, therefore reducing time and number of projects is suggested
Technology used	5 Excellent	Children were exposed to the latest technology; no suggestions were needed.
Class arrangement	3 Fair	For preschoolers, it is more comfortable to use a circular arrangement in class, with an instructor in the middle, and a more comfortable desk is suggested, for a one-hour duration. Moreover, five minutes snacks is recommended during the lesson.

1-Poor ,2 – Fair, 3 – Average, 4 – Good, **5** – Excellent

4.5 Developing and Selecting Instructional Materials

The lesson plan of the course was designed by the SME and the researcher, for preschoolers and it was reviewed by the ECE expert for modification purpose, moreover the researcher cooperated with the SME and the instructional designer to select appropriate resources for early learners, since resources was an essential part in developing the activities. The SME, researcher, and instructional designer were responsible to produce resources related to each topic, and to design the lesson plan, however, approval from the ECE expert was necessary before the production phases. Since young learners can be distracted easily, the lesson had to be carefully designed, and the lesson plan flow must have been entertaining. This was achieved by building different projects. Moreover, the instructor must be friendly with the kids to capture their attention because each activity had an aim to encourage learners to use their skills.

The activities were designed to teach different topics (Math, Science, Engineering and technology), using the latest technological devices. The class environment was arranged in a friendly way for early learners, and in each session, parents were allowed to attend as well. Figure 5 represent the bionic arm that was introduced on session 3; this bionic arm can be controlled by a glove; learners were so excited to try the glove and control the bionic arm.

Figure 5. *Bionic Arm*

4.5.1 Activities than enhance analytical thinking skills.

Since the activities' purpose was enhancing CT skills, the product was designed to boost learners analytical thinking. As shown in Figure 6 the CT resources are distributed to learners in a package with instructions , where the children have to sort the resources according to the instruction in the picture. Learners have to use their previous knowledge and analyses in each piece and figure out how it works.

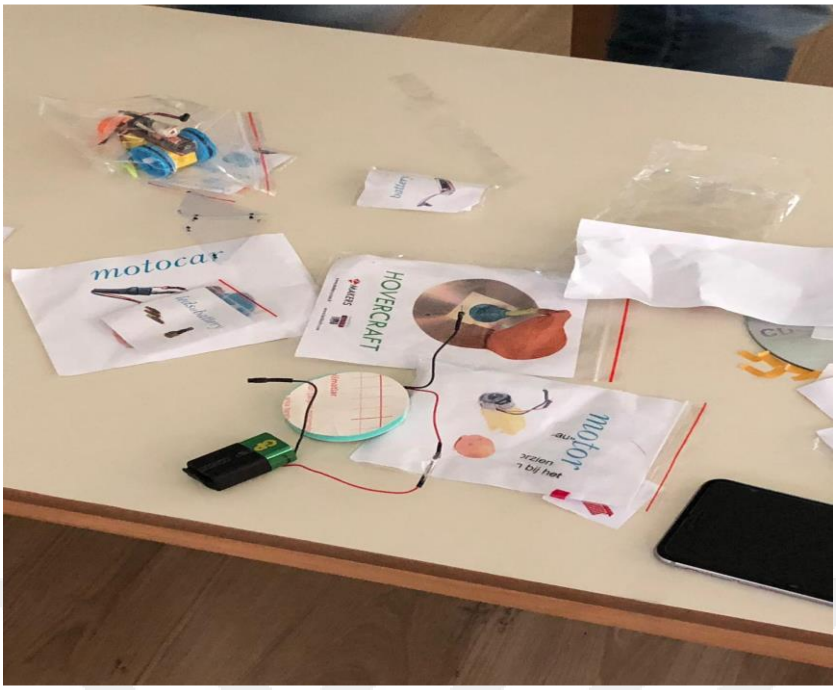


Figure 6. *CT Resources*

Learners were expected to perform motor skills activities such as sorting, coloring, and cutting, to build their project. Figure 7 represents resources used to build the bionic arm. Learners can easily follow the instructions since activities were designed to match their skills by giving easy instruction for the kids through colors matching.

Figure 7. *Bionic Arm Resources*

4.5.2 Activities that enhance communications skills

Figure 8 represent a laser game, where learners had to cross the laser light to find the treasure. When they didn't succeed, a sound popped, and when they finished the game, they took their prize. This encouraged learners to communicate and motivated them to learn, hence learners started communicating with the instructor and asked him how things worked. Figure 9 is a coding game, where learners have to follow their friend's instruction to cross the road and find the treasure. In this game, two teams can be created, with the instructor's guidance, children will try to follow the coding instruction to finish the game.

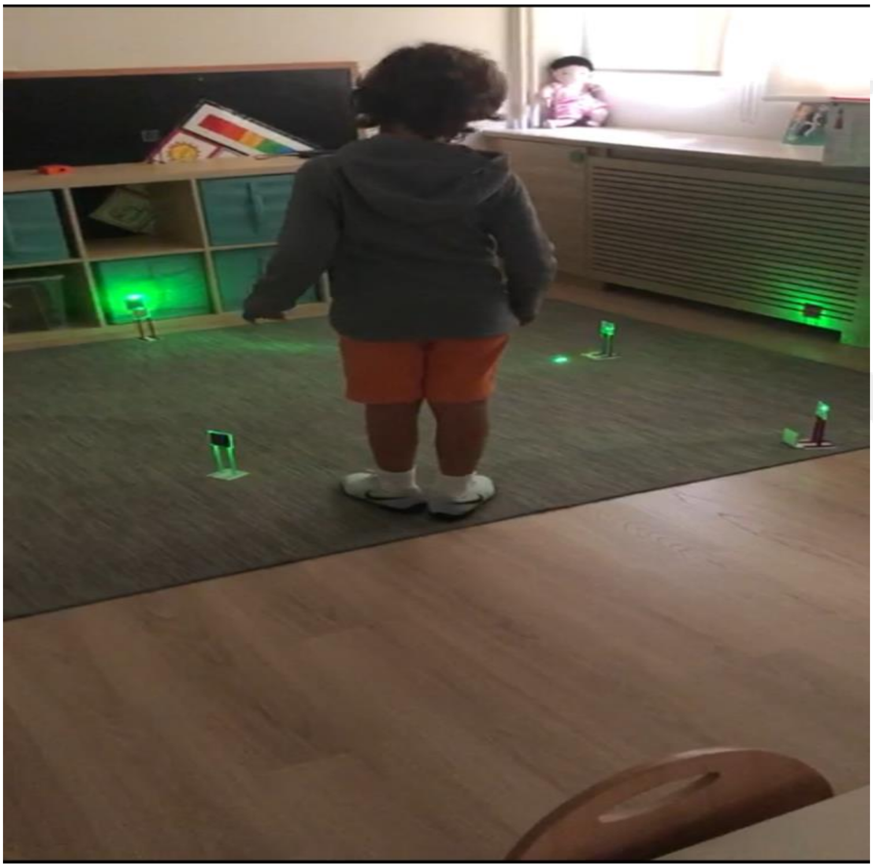


Figure 8. *Laser game*

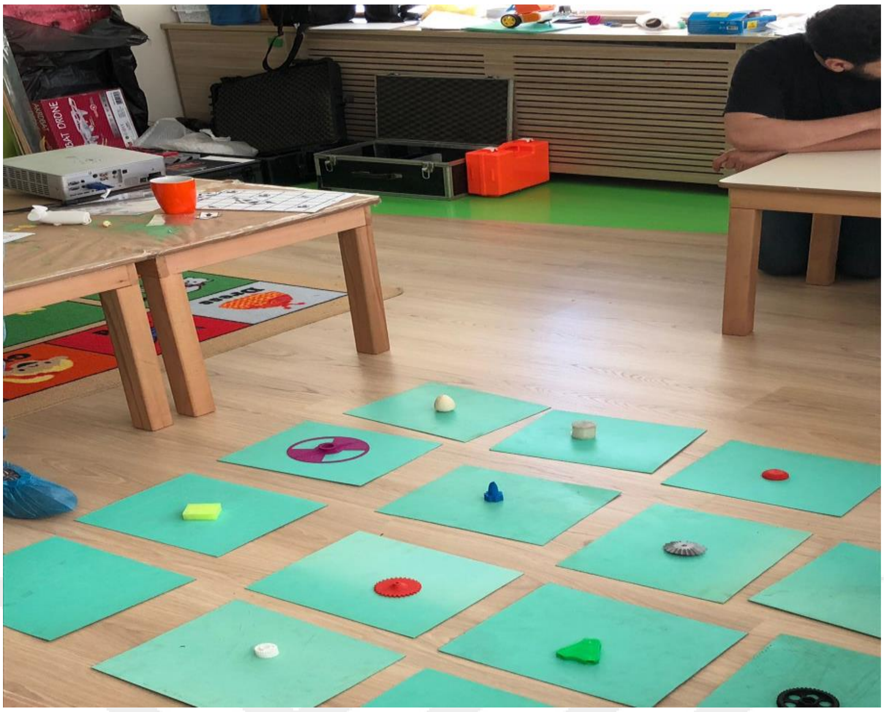


Figure 9. *Coding Game*

4.5.3 Activities than enhance problem solving skills

When hydroelectric power was introduced, the instructor distributed materials for the learners to figure out how it works. Figure 10 represents one of the resources used to teach hydroelectric power. After the learners were given time to investigate, they were introduced to the robotic hand that works using hydroelectric power. Since the robotic arm was introduced before, learners linked how they can produce a robotic arm that works using water and a needle instead of robes (See Figure 11).

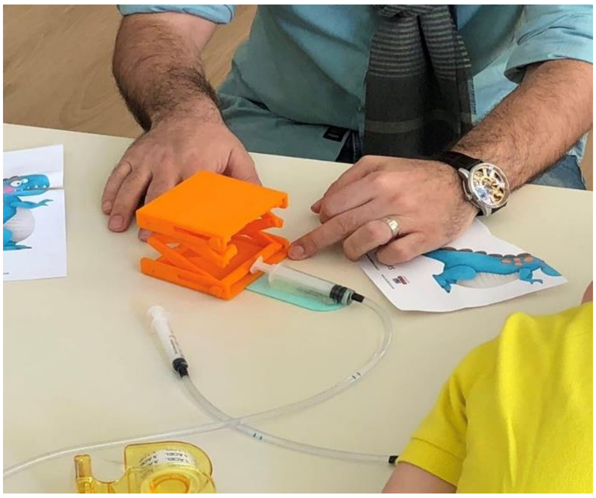


Figure 10. *Hydroelectric Power Resources*

Figure 11. *Bionic Arm that Operate Using Hydroelectric Power*

4.5.4 Activities that enhance creativity skills.

Introducing the learners to a new building machine that functions using hydroelectric power to hold a paper cup; a machine was produced using colorful material from a 3 D printer, where three different colors were used to distinguish its functionality. Each color represented a different move that the machine does (see Figure 12).

Figure 12. *Building Machine*

4.5.5 Activities than enhance open-minded skills

To enhance open-minded skills, learners had to produce their final project. However, they had the freedom to choose how to finalize it; for example, in one of the workshops, learners had to build a car, but they had the option to use either motor and battery or a balloon to make their car work. Each learner produced a different product using information from the previous workshop. See Figure 13, and 14.

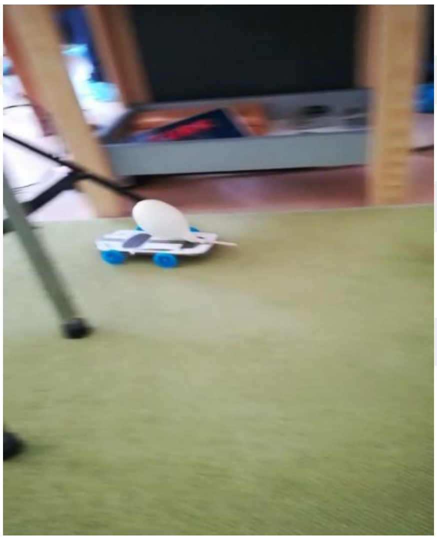


Figure 13. Car Working Using Air Power

Figure 14. Learners Building Their Car

4.6 Designing and Conducting Formative Evaluation

In order to measure the effectiveness of instructional design, one-to-one and small group formative evaluations were conducted, (1) the subject matter expert, researcher, instructional designer and ECE expert, evaluated and examined the developed instructional material and completed the expert assessment form, (2) one to one learner's perception toward the designed material was examined, (3) small group evaluation to measure learner's development in terms of their skills was conducted.

4.6.1 Formative evaluation of selected material and instructor lead instructions.

Tables 13 and 14 summarize feedback on the instructions across by three periods: the first 3 weeks of the workshop, the second three weeks, and the final four weeks. This type of instruction aims to evaluate the lesson plan and the selected materials, to revise any weakness in the instructions, and to give feedback for the instructor designer and the SME, to redesign the activities and, adjust the lesson plan if needed. Table 15 also summarizes the researcher note on the instruction and represent the change that were made to adjust the instruction according to the learners' needs.

Table 13

Formative Evaluations on Instructor Lead Instructions.

Instructions	Period 1	Period 2	Period 3
1) Are the instructions convincing, helpful and knowledgeable?	3	4	4
2) Is the instruction able to avoid digression and keep instruction and discussion on relevant topic and on schedule.	2	3	4
3) Does the instructions make presentation in an interesting clear manner	4	4	4
4) Does the instructor use visual aid to give example	4	4	4
5) Does the instructor provide feedback to learner's questions?	3	4	4
6) Does the instructor provide adequate practice exercise with feedback?	3	4	4

1-Poor ,2 – Fair, 3 – Average, 4 – Good

Table 14

Formative Evaluations on Selected Materials

Instructions	Period 1	Period 2	Period 3
1) the transition between source are smooth	3	4	4
2) the flow of content in the various instructional resources is consistent and logical	3	3	4
3) does the instructor have adequate sample to present	4	4	4
4) the vocabulary used is appropriate	4	4	4
5) the resources are appropriate for the target group	3	4	4

1-Poor, 2 – Fair, 3 – Average, 4 – Good

Table 15

Adjustment to Instructions

Task before adjustment	Task after adjustment
Watch YouTube video about the topic, and distribute materials while the learners are watching	Do not give learners resources while watching video, it distracts their attention
Instructor demonstrate how to build the project for the learners, while standing far.	Instructor should sit in the middle, and work with the learners step by step, early childhood has the ability to follow instruction when instructor is sitting in the middle, so all of the learners have the chance to follow him.
Break was not given	Five-minute break for water and toilets
Instructor explain the topic verbally	Less verbal, more action
Less question using metacognitive strategy was directed to the learners	Assigning five-minute question and answer session for the learners
No group work	Having group work
No assignment	Home assignment

4.6.2 Learners' perceptions on toward the Instructions.

The purpose of this subsection is to report the learners' perceptions on the instruction. The researcher conducted one to one formative evaluation with 15 learners to gather their perceptions on the instructions and materials. The researcher analyzed the data from the learners and formed a general summary of learners' perceptions, by filling the learner's perception form (see Table 16 and Figure 15).

Table 16

Learners' Feedback on Instructions

I can explain the project	STU1 Reflected his understanding to 3 D printer when he asked "*how many layers does this object has"*	3D printer was used as a sample in the session and each student created their own sample
	STU 2 reflected his understanding to hydroelectric power when he said that "*bionic arm can work using hydroelectric power"*	A sample was created by the instructor on the following session, so learners can understand how to use hydroelectric power in all cases.
I can use feedback from friend and teachers	STU 3 mentioned that "*yes teachers help me "* STU 5 "I *only understand Mr. M"* STU 6 *"I can do all the project alone"*	For every three learners one teacher assistant was presented in the workshop
I can say why an idea is a good one	STU 8 reflected his understanding toward magnetic force when he mentioned "I *will design my own magnetic pen, which right by its own"*	A magnetic drawing machine was brought on the next session for the learners to observe
	STU 14 mentioned that *"Magnetic car can go forward or backward when we change magnet direction"*	The learners created their magnetic car and tried to make it work using another magnet.
I can use information from different place	STU 9 mentioned that *"Mr. Murat videos help me to understand"* STU 12 mentioned that "*The toys that Mr. Murat brings help me to understand"*	Video session and different product were introduced to the learner at the beginning of each session.

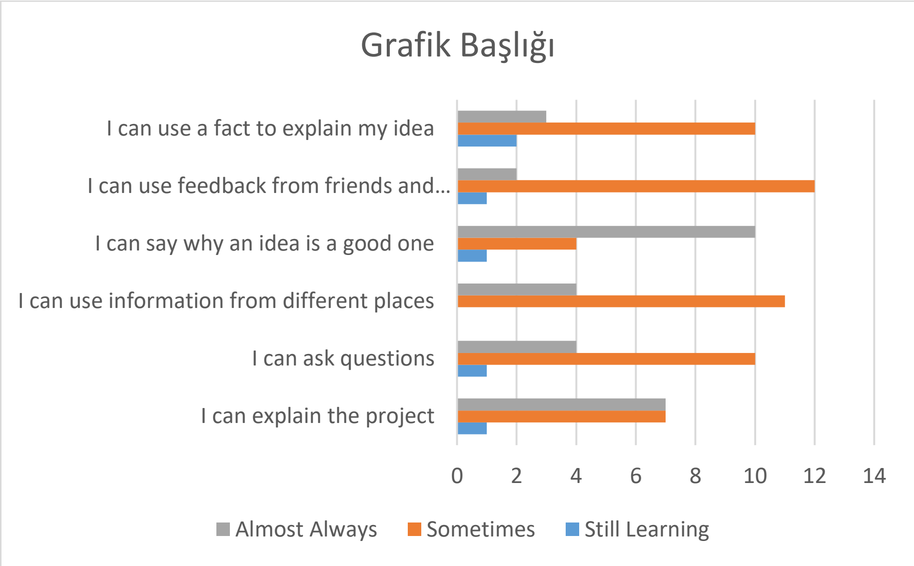


Figure 15 Learners' Perceptions on Instructions

The result explains that most of the learners' opinions were positive on the instructions, however, most of the learners answered "sometimes" when they were asked about their ability to explain their ideas and ask their peers, and this is related to the communication skills, which usually requires time to be developed among early learners. Moreover, the learners gave positive results when they were asked if they can explain the project. This was due to the well-designed materials, which have instructions with images that help the learners understand how to build and why this project was done. The learners also said "sometimes" about getting information from different places, which is also related to their communication skills, which can be developed with practice (see Table 17).

Table 17

Learners Perception Toward the Designed Instruction

	I can explain the project	I can ask questions	I can use information from different place	I can say why an idea is a good one	I can use feedback from friends and teachers	I can use fact to explain my idea
STU 1	2	1	2	1	2	1
STU 2	2	2	2	3	2	2
STU 3	2	2	2	3	2	2
STU 2	2	2	3	2	2	2
STU 3	2	2	2	3	2	2
STU 6	1	2	3	2	2	2
STU 7	3	2	2	3	2	3
STU 8	3	3	2	3	2	2
STU 9	3	2	2	2	2	2
STU 10	3	3	3	3	3	3
STU 11	2	2	2	3	3	3
STU 12	2	3	2	3	1	1
STU 13	3	2	3	3	2	2
STU 12	3	2	2	3	2	2
STU 13	3	3	2	2	2	2

1= Still learning, 2= Sometimes, 3= Almost always

4.6.3 Learners' development in terms of their skills

Small group evaluation was conducted following one-to-one evaluation to identify any learning problem that the learner might still have. One of the measurements to evaluate the instruction effectiveness is to measure the learner's performance score on pretest and posttest, where pretest typically encompasses the entry behavior skills, and posttest measures the learner's performance on terminal objectives of the instructions (Dick, Carey & Carey, 2005). In regard to learners' skills development, learners' entry skills were completed by the ECE expert, and these skills were related to CT skills while the researcher was writing notes for the performance of each student by completing the data progress report. Video analysis was used to complete any missing information related to each student. Table 18 summarizes the average progress of learner's skills since the start and end of the workshop, in which minimum and maximum scores for each type of performance along with their means and standard deviations are provided.

Table 18

Learners Skills Performance During Three Periods

	N	Minimum	Maximum	Mean	Std. Deviation
Analysis (1st Period)	15	20.00	30.00	26.00	5.07
Analysis (2nd Period)	15	30.00	50.00	41.33	6.40
Analysis (3rd Period)	15	50.00	60.00	52.00	4.14
Communication (1st Period)	15	10.00	30.00	26.00	10.57
Communication (2nd Period)	15	10.00	60.00	40.67	17.10
Communication (3rd Period)	15	10.00	60.00	46.67	17.65
Creativity (1st Period)	15	20.00	40.00	31.33	5.16
Creativity (2nd Period)	15	30.00	50.00	44.00	6.32
Creativity (3rd Period)	15	30.00	60.00	53.33	8.17
Open Mindedness (1st Period)	15	20.00	40.00	22.67	7.04
Open Mindedness (2nd Period)	15	20.00	60.00	40.00	10.71
Open Mindedness (3rd Period)	15	20.00	60.00	48.00	16.56
Problem Solving (1st Period)	15	20.00	40.00	26.67	7.24
Problem Solving (2nd Period)	15	30.00	50.00	40.00	5.34
Problem Solving (3rd Period)	15	40.00	60.00	51.33	5.16

With respect to analytical skills, scores ranged from 20 to 30 during the first period, 30 to 50 during the second period, and 50 to 60 during the 3rd period. It is important to note that 60 is the maximum score achievable. Means during these three periods increased gradually from 26 to 41.3 and finally to 52. This indicated a homogeneous and all-inclusive evolution in analytical skill among students over time. The standard deviation was relatively stable, indicating a stable stepwise increase in the group score.

Communication skill evolved rather differently, with scores ranging from 10 to 30 in the first period, and 10 to 60 in the second and third periods. Unlike analytical skills; in which no student remained at the lower end of the score, in communication skill, some students kept receiving scores of 10, thus increasing the range of achieved scores. However, the mean scores over the three periods for communication increased from 26 to 40 and finally to 46; thus, implying a group score increase over the three periods. Standard increased from 10 to 17 and remained at 17 during the 3rd period as this was due to the increase in the range of scores. Creativity evolved similarly to analysis, with ranges from 20 to 40 during the first period, 30 to 50 during the second period, and 30 to 60 during the last period. All other parameters are closely related to the evolution seen in analysis.

Open-mindedness had a similar evolution to communication, whereby score ranges were from 20 to 40 during the first period, followed by 20 to 60 during the second and third periods. The important thing was that the mean evolved from 22, to 40, and then to 48 in the third period, which indicates that the group evolved as a whole. The standard deviated reacted the same way as in communication. Problem solving skills evolved just the same way as analysis and creativity, with ranges evolving from 20 to 40 in the 1st period, and 30 to 50 in the 2nd period, and 40 to 60 in the third period. All other parameters behaved the same way as in analysis and creativity. In general, it can be seen that the ranges of scores tended to increase towards higher scores, with higher means for groups, and generally stable standard deviations. The smaller the standard deviations, the more concise the alteration is towards higher scores – and that was the case in all skills except “Communication” and “Open mindedness” where the standard deviation was skewed due to higher values due to the increase in the range of scores

Chapter 5
Discussion, Conclusion & Recommendation

This study aims to design, develop and evaluate activities which enhance CT skills for preschoolers, and that was completed by considering the learners' characteristics, and conducting need analysis, hence these activities were developed based on the stages of ADDIE model. The following section below discusses the findings that were obtained from this research.

5.1 Analysis

The result of the needs analysis to design CT activities for preschoolers was obtained from the outcome of the interview that was conducted with the SME, ECE Expert, and instructional designer. The result stresses on the importance of teaching 21-century skills in preschool, since the stated skill can be developed and enhanced through direct instructions, which will help the learner to develop their cognitive, thinking, and communication skills. As the result obtained from the ECE Expert emphasized that everyone has a creative side they might not know how to use it. Hence it is our role as an educator to help the students explore their creativity and stimulate their imagination. Moreover, this was stated by different scholars in the literature who emphasized on teaching 21-century skills, for example, Dede (2010) stressed that the emergence of information and communication technology had necessitated the development of certain key skills among younger generations. Moreover, DiBenedetto (2018) added that individuals who possess 21-century skills are with greater advantage than individuals who do not.

Additionally, both the ECE Expert and the SME highlighted that CT skills should be taught to preschool students because these are crucial skills for life, therefore every educator wants to teach CT skills to their students. However, educators still lack knowledge regarding CT skills and how to teach it. Moreover, the literature emphasizes the importance of teaching CT skills. According to McPeck (2016), an individual who thinks critically has certain characteristics that involve skepticism towards what is given. Consequently, a critical thinker questions the credibility behind the given statements and situations and seeks to find answers that satisfy his/her thought processes. This use of cynicism is equipped with experiences and experimenting, and it is not based on non-evidence-based opinions and notions.

In addition, in preschools, CT skills are being taught through play, music, science, and arts by letting the child explore the surrounding. However, there is a lack of defined activities with assessment scales according to each activity to teach such skills, that is why, educators can find it hard to assess the development of a child because of the absence of rubrics. The ECE Expert indicated that preschoolers gain CT by playing with toys, communicating, being exposed to basic arts, maths and science, however, there is no curriculum to follow with appropriate instructions for the educators. This also finds support in the literature. According to Smith & Szymanski (2013), CT has been ignored in preschools, and children leave preschool lacking those skills. Moreover, Choy & Cheap (2009) assure that there is no integration of CT skills in the curriculum of the preschools.

The result of the interview with the ECE Expert and SME reveals that there is a lack of teaching CT skills in preschools in Turkey. Therefore, designing a curriculum that teaches CT skills using the 21st century principles, such as using technological tools, has become essential in this century. Additionally, the SME emphasizes the importance of using technology in preschools to enhance young learners' skills and teach them in a playful context as it has been discussed in the literature review that teaching in preschools can be through plays. Broadhead (2006), assume that children learn while playing, since they use their imagination and this environment can be created with other children or on their own.

5.1.2 Learner and context analysis.

The results have been obtained to identify the characteristics of the learners, which were analyzed by the ECE Expert and the researcher later on. This analysis raises the awareness on the importance of teaching CT skills to preschoolers, because the scores of essential skills were low. To give an example, the skill for being open-minded is an important skill that should be taught today due to the rapid change in technology and inventions. It is revealed by various studies that CT skills can be taught. According to Karadag and Demirtas (2018), when “Philosophy for Children” curriculum is used in preschools to teach CT skills, the children showed improvement in performance. Moreover, another study by Lawi S.Y. (2006) implies that using picture books can stimulate children’s CT. Since CT skills cannot be gained naturally, educators should attach importance to teach CT skills.

Additionally, when the SME and the instructional designer analyzed the learners by giving them variety of materials to see what interested them, the learners showed interest in technology embedded resources and toys such as bionic arms, 3D shapes, LED lights and an electric circuit. Hence, the instructional designer and the SME planned the workshop by teaching different disciplines (Math, Technology, Engineering and Science), with the support of technology to facilitate learning. The lesson plan was related to STEM education, similarly, Kennedy& Odell (2014) infer that teaching the four disciplines math, science, engineering and mathematics by integrating technology will promote CT for K-12 students and will improve students’ engagement, which will improve communication and other CT skills.

The ECE Expert analyzed each child according to their learning preferences as well, and the result revealed that 90% of the learners prefer technology & robotics, especially the male learners. Furthermore, this result was obtained when their parents were asked about what their child prefers to do at home, and these results were similar to the findings of another study in the literature. According to Campbell & Jane (2012), technology in education promote learning since it motivates children to learn and create solutions to specific needs in an innovative way.

5.1.3 Conducting instructional analysis/writing performance objectives/developing assessment instruments.

As a result of interviews with experts, skills and entry behaviors were determined, and the SME and the researcher created the chart for designing CT activities. A similar chart for the development of CT activities was not found in the literature before. Consequently, this chart and information offers a new insight to the subject for other researchers. Even though the chart does not exist in the literature, each step of the lesson was supported from the literature, as for teaching analytical skill, seeking information can encourage higher level thinking skills “Understanding, applying, analyzing, evaluating”, that will enhance CT skills (Coffman, 2013), learners during the workshop were motivated to find information from their classmates, instructor, sample in the class or video, so they were be able to finalize their project and add their creativity on it, which is also mentioned in one of the studies in the literature (Stegelin, 2005) by giving space and free play to early learners to discover and solve complex problem enhance analytical thinking skill. Additionally, creativity skills were boosted by designing some robotic activities, since Robotic activities enable students to enhance 21-century skills, such as learning and innovation skills, creativity, CT, problem-solving, communication (Black & Zeigler, 2011). Moreover, open minded skills were developed by allowing the learners to do their unique product, with minimum teacher assistant, the instructor intended to monitor the learners, and guide them without interfering directly (Lennon, 2014). Solving problems or puzzles that come in many forms and require the application of complex reasoning and information processing enhance CT.

The five CT skills; each skill leading to different subskills, were chosen based on the literature. Therefore, lessons were planned to map each instruction with different skills, following the Bloom’s Taxonomy Hierarchy (Bloom, 1976; Anderson et al., 2001). In this research, the activities were designed to teach CT skills which were supported by the literature (Kasten ,2012, Marin and Halpern, 2011). The lesson structure consisted of video sessions and five different hands-on projects. These projects were designed in a way to start off simple and later progress into more challenging and more complex activities. Furthermore, the learner’s skills enhance overtime, since each project aims to develop specific skills. However, when the activities were developed, the instructional designer focus was on building activities that would boost the communication skills of young learners.

5.1.4 Developing instructional strategy/developing and selecting instructional material.

The instructional designer explained the flow of the lesson, and how each step was linked to CT skills and related subskills. It was found that there was no problem with the lesson flow, however some suggestions were raised up by the ECE expert to modify the flow of the lesson. Firstly, the lesson was planned according to the latest version of Bloom's Taxonomy Hierarchy, aligned with the literature that students gains CT skills by resolving an authentic problem or obtaining information while relying on and building upon their previous knowledge and experiences (Kirschner, Sweller, & Clark, 2006). Hence, it started by asking questions about the topic to the learners, as mentioned in the literature that asking open ended questions enhance early learners' CT skills (Gerde, Schachter, & Wasik, 2013). The instructor makes an evaluation if learners can remember or recall an idea, if so, this is linked to communication, and analytical skills according to CT. As the learners start to brainstorm some ideas, the instructor let them watch a video related to the topic so they are able to link the new information with the information they already have. This is the second stage in Bloom's Taxonomy, and this can be linked to analytical thinking and creativity in CT skills. However, some learners lack communication skills, due to different reasons, the researcher and the ECE expert suggested adding games and forming group, hence the lesson plan hierarchy was modified, and this was supported by the literature (Tsai et al., 2013) that students' CT can be enhanced by playing and doing activities.

For each session five different projects were designed according to the level of difficulty, and each step aimed to develop specific CT skills among learners. In the sixth session which aimed to teach animation concept, the learners were introduced to Scanimation, which is the first concept in animation design. Learners had to analyze the idea by interpreting information and trying to solve how it functions. In the second step the Praxinoscope was presented, which is the second inventory in animation design. This allowed the learners to compare between two projects and develop more understanding, which is the analysis step in Bloom's Taxonomy. This step boosted their creativity and analytical skills. Following the previous steps, the learners were introduced to book page flip. They evaluated and argued the product and then created their own flipbook following the instructions from the instructor. The final step was enhancing the learners' skills of being open-minded by letting them create their own animation story using tablets and working on animation program. Hence exposing early learners to well-structured and organized activities that is related to science, math or physics can enhance their CT skills, as proposed by scholars who found that early exposure to science education has led preschoolers to feel comfortable while getting education in later stages of life (Beering, 2009). Furthermore, according to the National Research Council (2005) teaching high-quality science learning experiences in early development pay off with increased long-term achievement and student engagement regarding science.

5.1.5 Designing and conducting the formative evaluation.

The result of the expert evaluation on the selected material and instructional lead instructions revealed some problems, which were reviewed and adjusted by the instructional designer and the SME. During the first sessions, material was distributed to the learners before demonstrating how the project should be done, hence this created distraction among early learners. This was solved on the following sessions when the instructor explained his idea in a fun and play context, which is similar to a study by Honig (2007) that children can enhance their cognitive skills by playing, since they learn how to wait, share and discover their surroundings. Therefore, the instructional designer, build challenging resources, which made the learners excited by seeking information and communicating with their classmate, and competing to build the best product, as suggested by (Howard, Jenvey & Hill, 2006), this will make learning more affective and will enhance the learner CT skills.

In this study, the learners who participated in the evaluation expressed some difficulties in following some of the instructions. This occurred especially during the first period, so the instructions were adjusted according to the researcher's comments and in respect to early childhood education. The learners expressed a positive opinion on the designed product and the lesson flow were adjusted accordingly.

On the other hand, most of the learners had negative perceptions when the instructor spent too much time for explaining the instructions. Early learners learn best when they perform activities, and learning can be assessed by observing the learners and giving them time to discover their surroundings. This result was aligned with the literature, that is, one way that children can learn is by playing that can be realized through activities to teach math, science, arts, writing and reading (Santer & Griffiths, 2007). Moreover, children develop their cognitive, emotional, physical, and creative skills through plays by exploring their surroundings (Stegelin, 2005). This was adjusted and improved for every session following the ECE Expert's and the researcher's feedback. Hence, the SME and instructional designer followed different strategies to teach CT skills, and these strategies were aligned with the literature.

Moreover, the researcher and the ECE Expert's feedback on the instructions and the designed course materials and course content were consistent. However, the instructor did not follow the lesson flow, which led to a time extension and this distracted the learners. Early learners can stay undistracted only for one hour if that period was divided into different activities, which last only 10 minutes each. Otherwise, they lose their focus and start roaming around. According to Chandler & Tricot (2015), children should spend less time on directed learning, and they should be let move freely by doing activities that they choose and spend more time in a passive learning environment. The researcher and the ECE Expert also emphasized that there was no problem in the communication of the instructor with the students. That is, the instructor gave constant support to the learners by explaining things in detail. Besides, the instructor used visual materials which were produced by the SME and the instructional designer to explain his ideas. Such materials are unique, and learners expressed motivation when using them. For example, in one of the sessions, the instructor explained about 3D animation, and virtual reality box was used, so learners were exposed to the latest technology. By doing so, the learners understood the concept of virtual reality as well as 3D animation at the same time while enjoying themselves.

The formative evaluation on learners' skills revealed positive results, to clarify, learners gained CT skills during the workshop gradually. The activities that were designed boosted the learners' skills due to the focused lesson plan which was adjusted by taking into consideration the feedback of the researcher and ECE Expert. Various feedback was obtained from the learners indirectly during the formative evaluation. When the

SME and the instructional designer gave each learner three different projects to build, the learners combined different projects to produce a brand-new item, which reflects their understanding, and this was a sign of development in the skills of being open-minded and analytical skills. At the end, the learners combined two projects to produce a third item which is a cleaning car.

5.2 Conclusion

The focus of this study was to provide insight into the significance of enhancing CT skills of preschool students by developing and designing new activities, that focus on enhancing 21st century skills, the implementation of the designed CT activities into the classroom setting offered opportunities to experience real-word activities with preschool students, and it offered the opportunities for the instructors to gain experience, and to enhance the activities to meet the learners need. Moreover, this study provides a new approach and strategies to teach CT skills to preschoolers since it focuses on the importance of achieving this skill at an early age. In today’s classrooms, there is a lack of attention paid to teach CT skills by designing activities using high technology, and teaching different disciplines based on project-based learning. The CT activities that were designed in this study resulted in positive feedback among preschoolers who showed interest and motivation towards the designed activities while showing a significant progress in their CT skills. Hence, the results underline the importance of promoting CT skills in classrooms today. In addition, there is a need of investing in appropriate resources that facilitate teaching and learning for both teachers and learners in order to see continuous progress in learning. In conclusion, the findings of the study indicate that preschool students can gain CT skills through project-based activities, in other words, young learners can gain skills by being given the right instructions.

5.3 Theoretical Recommendation

A number of recommendations for further research emerged through the results and discussions of this study. First, this study utilized a development approach to design new activities, where CT skills and sub-skills are embedded in the instructions. The researcher used the activities that were conducted in 10 sessions to validate the activities. However, since this study was limited to one school, the results cannot be generalized. Therefore, it is recommended that other researchers replicate the same study on a larger sample to check whether some additional methodology is needed for the results found in this study. A study with a larger sample would contribute to the field of education in terms of improving the teaching methods by adding different activities or adjusting the time or the teaching method. This will contribute to a new way of teaching CT among preschoolers. Furthermore, young learners' assessment can be enhanced to match a larger sample. In this study, observation and video analysis were used. This might not be practical for a larger sample, therefore using the same study on a large population would lead the researcher to develop a standardized rubric to assess preschoolers' CT skills.

Moreover, certain suggestions are proposed for future research and for better performance in the related field. May this study be used in the future;

- data should be run on a larger sample of learners that come from different backgrounds, which provides diversity among participants,
- more than one ECE Expert should be involved,
- A special needs psychologist should be involved to improve the activities designed for them to be applicable for children with special needs as well,
- it should compare two groups; an experimental group that is exposed to these activities and another group that is not, which in turn will be easier for assessment,
- standardized scaling rubric should be designed regarding CT skills and sub skills,
- a booklet should be prepared to lead the educators about how the lesson flow should be carried out.

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APPENDICES

A. Expert Validation Form

Activities validation form

Instructional quality for designed Critical thinking activities for preschoolers.

Class : Date:

Direction: we need your help to evaluate the designed activities for ppreschoolers the left columns name particular parts of the lesson.fr each part named rates its overall quality on a scale. 1 = poor to 5= good. Kindly write your suggestion to improve the activities level.

Lesson part	Quality rating	Suggestion
Introduction:	Poor 1-2-3-4-5 Good	
Objectives:	Poor 1-2-3-4-5 Good	
Material quality:	Poor 1-2-3-4-5 Good	
Lesson flow:	Poor 1-2-3-4-5 Good	
Technology used:	Poor 1-2-3-4-5 Good	
Class arrangement:	Poor 1-2-3-4-5 Good	
Others:	Poor 1-2-3-4-5 Good	

B. Learner's Analysis Form

Learner analysis form		
1-Learners entry skills	See Appendences (Learners Entry skills form)	
2-Learners Demographics information		
Name:		
Gender	Male :	Female:
Age:		
Language Level:		
Prior topic knowledge:		
3-Attitudes about the delivery system		
4-Attitude toward the organization		
5-learning preferences		
Science		
Engineering		
Technology		
Art		
Technolog used at home		
6-group characteristics, and motivation		

C. Learners Entry Skills Form

Observaton Rubric

CT skills	Subskills	STU 1
Analytical	Asking Thoughtful Questions Data analysis Information Seeking Interpretation Questioning Evidence Recognizing Differences and Similarities	
Communication	Explanation Expressing Opinion	
Creativity	Cognitive Flexibility Conceptualization Curiosity Imagination Prediction Making Inferences	
Problem solving	Applying Standards Attention to Detail Collaboration Innovation	
Open minded	Objectivity Observation reflection	

D. Observation Form

Observaton Rubric

CT skills	Subskills	STU 1
Analytical	Asking Thoughtful Questions Data analysis Information Seeking Interpretation Questioning Evidence Recognizing Differences and Similarities	
Communication	Explanation Expressing Opinion	
Creativity	Cognitive Flexibility Conceptualization Curiosity Imagination Prediction Making Inferences	
Problem solving	Applying Standards Attention to Detail Collaboration Innovation	
Open minded	Objectivity Observation reflection	

E. Preschool Assessment Rubric

Preschool assesment rubric for critical thinking

STEM ASSESSMENT CRITERIA	Critical Thinking Skills	Emerging	Developing
Identifies some features and talks about those features s/he likes and dislikes	Open minded		
Communicates and cooperates with the STEM teacher; and shows interest and active participation to STEM activities	Communication		
Asks questions about why things happen and how things work	Communication		
Is able to work in a group and collaborate with peers	Communication		
Shows curiosity and interest by exploring surroundings	Creativity		
Investigates places, objects, materials and living things by using all senses as appropriate.	Analytical thinking		
Looks closely at and attempts to find out about similarities, differences, patterns and change	Analytical thinking		
Identifies the use of everyday technology and uses information and communication technology and programmable toy to support her/his learning	Analytical thinking		
Adds own creativity and builds different structures and products	Creativity		
Observes, selects and manipulates objects and materials.	Open minded		
Identifies simple features and significant personal events.	Problem solving		
Seeks and attempts to find solutions to simple problems with relation to the topic	Problem solving		

F. Evaluation Rubric on Selected Material and Instructor Lead Instructions

Rubric Formative evaluation of selected material and instructor lead instructions. Rating response 1. Not at all 2.Somewhat 3.Motly 4.Very	
elevation criteria	Researcher note
1) Is the instructions convincing, helpful and knowledgeable?	Interesting 1,2,3,4 Clear 1,2,3,4 Useful 1,2,3,4
2) is the instruction able to avoid digression and keep instruction and discussion on relevant topic and on schedule.	Interesting 1,2,3,4 Clear 1,2,3,4 Useful 1,2,3,4
3)does the instructions makes presentation in an interesting clear manners	Interesting 1,2,3,4 Clear 1,2,3,4 Useful 1,2,3,4
4) does the instructor use visual aid to give	

example 5) does the instructor provide feedback to learner's questions?	Interesting 1,2,3,4 Clear 1,2,3,4 Useful 1,2,3,4
6) does the instructor provide adequate practice exercise with feedback?	Interesting 1,2,3,4 Clear 1,2,3,4 Useful 1,2,3,4
	Interesting 1,2,3,4 Clear 1,2,3,4 Useful 1,2,3,4

G. Interview Result (Need assessment)

Answer	Code	Theme
ECE Expert *"21st-century skills are essential skills, and should be taught at the age of two years."* *"21st-century skills should be acquired since it affects student performance in primary and secondary school."* *"21st-century skills such as CT can be taught in preschool through play, art, music, it should be embedded into the curriculum."*	• Better performance. • Start at an early age. • Can be taught through different activities.	Insights about the importance of teaching 21st-century skills 1) At what age should 21st-century skills be taught 2) Why should 21st-century skills be taught 3) How to teach 21st-century skills
Subject matter expert (SME) *"21st-century skills should be taught at the preschool, which will contribute to better performance later in primary and secondary school."* *"students need to be able*	• Teach 21st-century skills at preschool • STEM and robotic education improve 21st-century skills	Insights about the importance of teaching 21st-century skills 1) At what age should 21st-century skills be taught 2) Why should 21st-century skills be taught 3)How to teach 21st-century skills

to demonstrate higher-order thinking skills and apply their learning. Since many of the challenges that our children will face in the 21st century do not have clearly defined answers." *" Well designed activities, STEM education, and robotics will lead to better thinking skills."*		
ECE Expert *"According to my expertise with children, communication and analytical skills are the most important skills for children."* *" When you give children CT skills, they will be able to find the necessary information for themselves; they will be able to evaluate the merits and consequences of that information, and they will be able to utilize that information to solve any problems at hand."*	• analytical, thinking skills and communication skills • CT leads to better problem solving • structured lesson plan • Minimum assistant	The importance of acquiring CT skills at an early age 1) What CT skills should preschoolers gain? 2) Why CT skills be taught at an early age? 3) How can CT skills be taught?

"CT skills can best be taught, through well-designed activities, and structured lesson plan, moreover teachers should give space to the child to discover the surrounding with a minimum assistant."		
subject matter expert (SME) *"There are no specific skills that child must gain, each child can master different skills "* *" Well designed activities, STEM education, and robotic education will lead to better thinking skills."*	• Teach 21st-century skills at preschool • STEM and robotic education improve 21st-century skills	The importance of acquiring CT skills at an early age 1) What CT skills should preschoolers gain? 2) Why CT skills be taught at an early age? 3) How can CT skills be taught?
ECE Expert "*Preschool in turkey are not teaching and assessing CT skills for preschool for a different reason, 1) lack of expertise in this domain, 2) the high cost to build CT activities for young learners*". "*Normal activities such as toys, that do multitask, art,*	• Lack of expertise • High cost for resources • Art, Music and multitask toys are used to teach CT skills	Lack of teaching CT skills at preschool. Why? What CT activities are being taught in preschools?

music is being taught to young learners, but there is no approved curriculum on activities that enhance CT skills for young learns and assessing what skills they had gained later."		
"Teachers have no experience in this domain." *"Lesson plan and curriculum must support teaching CT skills."* *"Preschoolers mainly teach art to enhance the children CT skills."*	• Lack of expertise • Teaching Art to enhance CT skills	Lack of teaching CT skills at preschool. Why? What CT activities are being used?
SME *"New activities must be designed to match learners needs, culture, age, background, skills."* *"Since we live in the 21st century, technology should be taught, and children must be exposed to new inventory."* *"Tablet, robot, virtual*	• Technology is developing rapidly children must be exposed to new inventory • All technology must be used to enhance learning	Designing activities to enhance CT skills, and adding technology to enhance learning. Why new activities should be designed? How can technology enhance learning? What technology should be used?

reality, augmented reality."		
Instructional designer *"Brand new activities can be adjusted according to learners need, besides producing appropriate resources related to the activities, which can be improved with time."* *"Technology motivated learners, especially young children who are always curious to learn new things."* *"Technology can be anything, book, pen or tablet, everything that enhances learning is considered technology."*	• Pen, books, and tablets are all technology • Children are curious about learning • Technology can motivate children	Designing activities to enhance CT skills, and adding technology to enhance learning. Why new activities should be designed? How can technology enhance learning? What technology should be used?

H. CT Questionare

Questioners

Critical Thinking Rubric for PBL
(for grades K-2)

I can explain why we are doing the project.
1. still learning 2. sometimes 3. almost always

I can ask questions about the project.
1. still learning 2. sometimes 3. almost always

I can use information I get from different places.
1. still learning 2. sometimes 3. almost always

I can say why an idea is a good one.
1. still learning 2. sometimes 3. almost always

I can use feedback from my friends and teacher to improve my work.
1. still learning 2. sometimes 3. almost always

I can explain my idea using facts and details.
1. still learning 2. sometimes 3. almost always

I. lesson Plan

CT Skills	Sub Skills	Lesson objectives	Instructor Comments
1.Vibrating toothbrush			
1.Analytical **2.Communication**	<u>Objective 1</u> • Asking Thoughtful Questions • Data analysis • Information Seeking • Interpretation <u>Objective 2</u> • Expressing opinions and ideas • Verbal Communication <u>Objective 3,4</u> • Observation • Reflection	1-Students will state how toothbrush can vibrate using battery 2-Students will explain why the battery made the toothbrush to vibrate. 3-Students will demonstrate how toothbrush can move in a different direction but adjusting the battery position while communicating with each other’s they can discuss which position is the best. 4-Students will differentiate between their product performance and their classmate’s products performance while making a race with	Creativity skills did not match this lesson plan since they did not create their own product, they were given instruction and followed the instructor guide to finalize their product.

4. Open-Minded **5.Problem-solving**	<u>Objective 5,6</u> • Logical Reasoning • Attention to detail • Innovative	their toothbrush. 5-Students will test how batteries can move an object. 6-Students will design a car that works on battery.	
2.Air pressure			
1.Analytical	<u>Objective 1</u> • Information Seeking • interpretation	1-Students will define what is gasses and how can air pressure be measured. 2-Students describe how air can move	Communication CT skills were not considered in this lesson plan. Different activities can be created to

2.Creativity 3.Open minded 4.Problem-solving	Objective 2 • Predicting • Foresight Making Abstract Connections • Making Inferences • Visionary Objective 3,4 • Objectivity • Observation • Reflection Objective 5,6 • Attention to detail • Clarification • Decision making • Evaluation • Innovative • Logical Reasoning	an object, by blowing a balloon and let the air inside it cause the vibration of pieces of paper. 3-Students will illustrate this experiment by building a car that moves on air pressure. 4- Students will examine how fast their car will go with the air pressure from the balloon 5-Students will judge that moving car-using balloon is not very effective as using electric power. 6- Students will design a new product that works on electric power.	enhance communication

3.Robotic hand			
1.Analytical 2.Communication 3.Creativity	Objective 1,2,3 • Asking Thoughtful Questions • Data analysis • Information Seeking • Interpretation • Judgment • Questioning Evidence • Recognizing Differences and Similarities Objective 4 • Asking important questions • Explanation • Expressing opinions and ideas Objective 5 • Cognitive Flexibility • Conceptualization • Curiosity • Imaginative • Predicting Objective 6,7 • Applying Standards • Attention to detail • Clarification	1-Students will recognize a different type of robotic hands while observing and watching videos the mechanics of moving a robot arm. 2-Students will be able to classify their materials, to produce the product. 3-Students will watch a humorous video about robots and will be able to describe what functions robots can do. 4-Students will be able to apply what they see in the video and build the robot arm 5-Students will explore how each finger is being moved. 6-Students will test if their robot arm can carry a cup of	

4.Problem-solving 5.Open minded	• Collaborative • Decision Making • Evaluation • Identifying Patterns • Innovative • Logical Reasoning <u>All objective</u> • Observation • Reflection	water 7-Students will be able to solve the problem if the robotic hand did not work properly.	
4.Magnetic Force			

1.Analytical **2.Problem-solving**	<u>Objective 1,2</u> • Data analysis • Information Seeking • Interpretation • Judgment • Questioning Evidence • Recognizing Differences and Similarities <u>Objective 4,5,6</u> • Applying Standards • Attention to detail • Clarification • Collaborative • Decision Making • Evaluation • Identifying Patterns • Innovative • Logical Reasoning <u>Objective 6</u> • Verbal Communication • Asking important questions.	1-Students will Distinguish between magnetic and nonmagnetic materials 2-Students will interpret that opposite sign of magnet attract and same sign rebel 3-Students will apply a magnetic force to do fishing, by playing fine Nemo game 4-Students will explore moving a magnetic car forward and backward. 5-Students will be able to justify why the car went forward or backward. 6-Students will practice what they have learned by moving iron sprinkles with a magnet, into the water and observe	This lesson plan focused on analytical skills and problem-solving, other skills were not cover completely due to lack of time. Since lots of activities focused on practice and problem solving

3.Communication		the result. Students played the bald head game with iron sprinkles	
5.Mirror			
1.Analytical **2.Communication**	Objective 1,2 • Asking Thoughtful Questions • Data analysis • Information Seeking • Interpretation • Judgment • Questioning Evidence • Recognizing Differences and Similarities • Skepticism Objective 1,2 • Explanation • Expressing opinions and ideas Objective 3,4 • Cognitive Flexibility • Conceptualization • Curiosity • Imaginative • Predicting	1-Students will recognize how mirror make a reflection, by applying a mirror to a different image and observing the result. 2-Students will interpret how a mirror can change shapes of an object 3-Students will implement their experience to produce periscope. 4-Students will discover the difference between telescope and periscope 5-Students will determine that using LED light with mirror will produce infinity mirror	

3.Creativity **4.Open minded** **5.Problem Solving**	• Making Inferences • Visionary <u>All objective</u> • Objectivity • Observation • Reflection <u>Objective 5,6</u> • Applying Standards • Attention to detail • Clarification • Collaborative • Decision Making • Evaluation • Identifying Patterns • Innovative • Logical Reasoning	6-Students will verify this experience by turning the light off and on.	
6. Art of drawing			

1.Creativity **2.problem solving**	<u>Objective 1,2,3</u> • Cognitive Flexibility • Conceptualization • Curiosity • Imaginative • Predicting • Foresight Making Abstract Connections • Making Inferences • Synthesizing <u>Objective 4,5,6</u> • Applying Standards • Attention to detail • Clarification • Collaborative • Evaluation • Identifying Patterns • Innovative • Logical Reasoning	1-Students will reproduce different shapes, by drawing on white paper using a specific ruler. 2-Students will recognize how dimension shapes; can be formed by combining different shapes. 3-Students will employee this information using special software for drawing. 4-Students will experiment drawing on a biscuit, by using the chocolate machine. 5-Students will support their idea by drawing image with a sand pendulum. 6-Students will create robotic drawing machine.	For this lesson two of CT dimension were applied, analytical skills and communication were not considered in this lesson plan, due to the following reason: 1-3 D is new concept for kids at that age, analytical skills might be required for another lesson about 3 D modeling. 2-Communication and group project were not preferred because each child imagination skills and ability to produce different shape must be measured.

7. 3D Modeling			
1.Analytical **2.Communication**	<u>Objective 1,2</u> • Asking Thoughtful Questions • Data analysis • Information Seeking • Interpretation • Judgment • Questioning Evidence • Recognizing Differences and Similarities <u>Objective 3,4</u> • Explanation • Expressing opinions and ideas <u>Objective 5</u> • Imaginative	1-Students will recall what 3D animation is by watching a video. 2-students will recognize that 3D has a depth which makes it different to 2D 3-students will employee these experience by building 3D shapes using blocks 4-students will compare different 3D shapes and figure out how many layers needed each shape to be built. 5-Students will support their understanding by drawing on a piece of paper and print the shape using a 3D printer.	Problem solving skills were not cover In this lesson, since 3D modeling required creativity by drawing object they could imagine, and convert it into real 3D object using 3D printer.

3.Creativity			
8. Virtual reality			
1.Analytical	Objective 1,2 • Asking Thoughtful Questions • Data analysis • Information Seeking • Interpretation • Judgment • Questioning Evidence • Recognizing Differences and Similarities	1-Students will define the meaning of virtual reality after watching a video. 2- Students will describe how image is formed in virtual reality, and why we use glasses to correct the image. 3-students will	This lesson encouraged students to communicate, ask more question, since it is very interesting, new concept, and requires technology, which encourage kids to participate in the lesson, and push

2.Communication **3.Creativity**	• Skepticism <u>All Objective</u> • Explanation • Expressing opinions and ideas <u>Objective 3,4</u> • Cognitive Flexibility • Conceptualization • Curiosity • Imaginative • Predicting • Making Inferences • Visionary <u>Objective 5,6,7</u> • Objectivity • Observation • Reflection <u>Objective 8</u> • Applying Standards • Attention to detail • Collaborative • Decision Making • Innovative • Logical Reasoning	interpret that 33images is formed by combining two images together, using blue and red color. 4-students will examine their interpretation by covering the red lens to see the blue image, and then cover the blue lens to see the red image. 5-Students will select different images and repeat the experiment until they are able to defend their experiment. 6-students will design virtual reality cardboard. 7- Students will investigate by watching virtual reality videos, using Phone that has cardboard application. 8-students will	them to seek for more information.

4.Open minded **5.Problem Solving**		develop more experience by learning the new mobile application and downloading them.	
9.Augmented Reality	9.Augmented Reality	9.Augmented Reality	9.Augmented Reality
1.Analytical	<u>Objective 1</u> • Asking Thoughtful Questions • Data analysis • Information Seeking • Interpretation • Judgment • Questioning Evidence • Recognizing Differences and Similarities • Skepticism <u>Objective 2</u> • Explanation	1-Students will state the difference between augmented and virtual reality, after watching a video about both contents. 2-Students will recognize that Technology should be used to dive into the world of augmented reality. 3-Students will implement their understanding by using Blippar	

2.Communication 3.Creativity 4.Open minded	• Expressing opinions and ideas Objective 3,4 • Cognitive Flexibility • Conceptualization • Curiosity • Imaginative • Predicting • Making Inferences • Visionary Objective 5,6 • Objectivity • Observation • Reflection Objective 7 • Applying Standards • Attention to detail • Collaborative • Decision Making • Innovative • Logical Reasoning	application, and scan a paper with dinosaur image. 4-Students will question the dinosaur by clicking on the image and communicating with it. 5-Students will select different dinosaur's images and learn their functionalities. 6-Students will investigate their surrounding using Blippr application to scan different object In the classroom. 7-Students will examine 360 cameras by shooting a video for their class. 4	

5.Problem Solving			

J. Curriculum Vita

GENERAL INFORMATION:

Surname, Name: Chaikh, Rana

Nationality: Syrian (Sy)

Date and Place of Birth: 26 April 1983, Damascus

Marital: Single

Telephone: +90 531 617 85 49

email: ranachaikhkoroush @stu.bahcesehir.edu.tr / ranachaikh @gmail.com

EDUCATION:

Degree	**Institution**	**Year of Graduation**
BS (Computer science)	Lebanese American university (Beirut)	2007
Master(Educational technology)	Bahcesehir university	2019

FOREIGN LANGUAGE:

English, Turkish

EXPERIENCE:

2007-2013 Qatar national bank (Head of MIS department)

2014-2019 Preschool education (STEM)

HOBBIESS:

Dancing, Traveling