REPUBLIC OF TURKEY
YILDIZ TECHNICAL UNIVERSITY
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ETHNOGRAPHIC CASE STUDY OF EARLY STEM EDUCATION: INVESTIGATING STUDENTS' AUTHENTIC LEARNING EXPERIENCES

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A thesis submitted by Şefika GİRGİN in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** is approved by the committee on 05.06.2018 in Department of Mathematics and Science Education, Science Education Program.

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LIST OF ABBREVIATIONS

APKS	Authentic Problem for Knowledge Society
BTHP	Bilgi Temelli Hayat Problemi (in Turkish of APKS)
STEM	Science, Technology, Engineering, Mathematics
YTU	Yıldız Technical University

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ABSTRACT

ETHNOGRAPHIC CASE STUDY OF EARLY STEM EDUCATION: INVESTIGATING STUDENTS' AUTHENTIC LEARNING EXPERIENCES

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MSc. Thesis

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Recent national initiatives in education have focused on improving access for young people in STEM careers. It is also important to make efforts to attract more students to scientific and technological achievements, since students can then be taken to the relevant professions. To develop outstanding performers in the field and also to improve the current economy and knowledge level of society, multi-disciplinary education with high quality is needed in science, technology, engineering and mathematics. Reaching this aim can be possible with skilled, responsible and inspired young students and the number of graduates in the field of science and technology should be increased. At the point of increasing it, STEM education has crucial role in order to drive critical thinking and innovation in today's society. In other words, STEM education provides an insight on students to be more innovative with 21st century skills and so if students experience these skills as early as possible, they can adapt to their future life more easily.

In this context, there is a need to integrate STEM into the education system and many countries around the world restructure their education system in this field to develop their innovative capacity. In the same manner, authentic learning provides an implementation of knowledge in real-life context and motivates students to handle with real life problems by experiencing hands-on learning in an authentic environment. In other words, authentic learning focuses on real-life related issues as STEM education and students have an active role during that process. From this perspective, STEM education, especially at primary level, provides knowledge and experiences that students can use them in an active and authentic environment. In this regard, a program called as "Early STEM" based on the framework of Integrated Teaching Project was developed for K-4 students. In the light of this program, one lesson hour per week was assigned and four themes (My Green World, My World of Machines, My

Computational World and My World of Imagination) based on STEM disciplines (science, technology, engineering and mathematics) were applied in these lessons. Each theme lasted 8 weeks and the program totally spread over eight months period. Also, the program was implemented within the plans prepared according to STEM Learning Cycline which was developed based on Constructivist 5E Instructional Model.

At this point, the present study aimed to investigate the students' authentic learning experiences in the early STEM lessons. In order to examine this aim in depth, ethnographic case study design was selected as the research design. Sample of the study consisted of total 13 4^{th} grade students and one classroom teacher who has prior experience on the early STEM program. In this qualitative ethnographic case study, evidence of authentic learning was collected from field/observation notes and transcripts from classroom observations for 8 weeks and face-to-face interviews with the students and teacher in socio-constructivist and interpretivist perspective and also by considering Authenticity Model and STEM Learning Cycline as conceptual frameworks.

As a result of the present study, three themes were emerged from 14 categories by using initial and process coding during data analysis. The themes are: 1) Authenticity vital role in early STEM education, 2) Early STEM effectiveness in authentic environment, 3) Essential role of early STEM education upon students' authentic learning experiences. These findings provide insight into how STEM education has a role in authentic learning experiences in early grades.

Key words: Early STEM education, authentic learning experience, ethnographic case study

ÖZET

ERKEN STEM EĞİTİMİNİN ETNOGRAFİK DURUM ÇALIŞMASI: ÖĞRENCİLERİN OTANTİK ÖĞRENME BECERİLERİNİN İNCELENMESİ

Şefika GİRGİN

Matematik ve Fen Bilimleri Eğitimi Anabilim Dalı

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Eğitim alanındaki son ulusal girişimler STEM kariyerlerinde genç bireylere erişimi arttırmaya odaklanmıştır. Öğrencilerin daha sonra ilgili mesleklere alınabilmelerini sağlamak amacıyla, daha fazla öğrenciyi bilimsel ve teknolojik başarılara çekebilmek önemlidir. Alanında seçkin bireyler yetiştirmek ve aynı zamanda toplumun güncel ekonomisini ve bilgi düzeyini geliştirmek için bilim, teknoloji, mühendislik ve matematik alanlarında yüksek nitelikli disiplinlerarası eğitime ihtiyaç duyulmaktadır. Bu hedefe yetenekli, sorumluk bilincine sahip ve ilham alan genç öğrenciler ile ulaşmak mümkündür ve dolayısıyla, fen ve teknoloji alanlarındaki mezunların sayısı da artırılmaya çalışılmalıdır. Bu noktada STEM eğitimi, günümüz toplumunda eleştirel düşünmeyi ve yeniliği teşvik etmek için çok önemli bir role sahiptir. Diğer bir deyişle, STEM eğitimi, öğrencilerin 21. yüzyıl becerileri ile daha yenilikçi olmaları noktasında bir fikir sunmaktadır ve eğer öğrenciler bu becerileri mümkün olduğunca erken yaşlarda kazanırlarsa, gelecekteki yaşamlarına daha kolay uyum sağlayabilirler.

Bu bağlamda, STEM'i eğitim sistemine entegre etme ihtiyacı duyulmuştur ve Dünya'daki birçok ülke, bu alanda eğitim sistemlerini yenilikçi kapasitelerini geliştirmek için yeniden yapılandırmaktadır. Aynı şekilde, otantik öğrenme de gerçek yaşam bağlamında bilginin uygulanmasını sağlar ve öğrencileri otantik bir ortamda uygulamalı öğrenme deneyimi yaşayarak, gerçek hayat problemleri ile başa çıkma noktasında motive eder. Diğer bir deyişle, otantik öğrenme, STEM eğitimi gibi gerçek yaşamla ilgili konulara odaklanır ve öğrenciler bu süreçte aktif rol oynarlar. Bu açıdan bakıldığında, STEM eğitimi, özellikle ilköğretim düzeyinde, öğrencilerin aktif ve özgün bir ortamda bunları kullanabilecekleri bilgi ve deneyimler sunmaktadır. Bu noktada,

okul öncesinden 4.sınıfa kadar olan öğrenciler için Bütünleşik Öğretmenlik Projesi çerçevesinde “Erken STEM” olarak adlandırılan bir program geliştirilmiştir. Bu program kapsamında, haftada bir ders saati erken STEM dersi olarak belirlenmiş ve STEM disiplinlerine (bilim, teknoloji, mühendislik ve matematik) dayalı dört tema (Yeşil Dünyamız, Makineler Dünyası, Bilişim Dünyası ve Hayal Dünyası) bu derslerde uygulanmıştır. Program her tema için 8 hafta olmak üzere toplamda sekiz ay boyunca sürmüştür. Ayrıca program, Yapılandırmacı 5E Öğretim Modeli'ne dayalı olarak geliştirilen STEM Çemgisi'ne göre hazırlanan planlar kapsamında hayata geçirilmiştir.

Bu noktada, bu çalışma, öğrencilerin erken STEM derslerinde otantik öğrenme deneyimlerini araştırmayı amaçlamıştır. Bu amacı derinlemesine incelemek için etnografik özel durum çalışması araştırma tasarımı olarak kullanılmıştır. Çalışmanın örneklemi erken STEM programı ile ilgili önceden deneyim ve bilgiye sahip bir sınıf öğretmeni ve 13 tane dördüncü sınıf öğrencisinden oluşmaktadır. Bu niteliksel etnografik özel durum çalışmasında, otantik öğrenme kanıtları 8 haftalık gözlemlerden ve öğretmen ve öğrenciler ile yapılan yüz yüze görüşmelerin transkriptlerinden, sosyo-yapılandırmacı ve yorumlayıcı bakış açısıyla toplanmıştır; ayrıca Otantiklik Modeli ve STEM Çemgisi de bu süreçte kavramsal çerçeve olarak dikkate alınmıştır.

Bu çalışmanın sonucunda, veri analizi sırasında başlangıç ve süreç kodlaması kullanılarak 14 kategoriden üç ana tema ortaya çıkmıştır. Bu temalar şunlardır: 1) Erken STEM eğitiminde otantikliğin hayati rolü, 2) Otantik ortamda erken STEM'in etkinliği, 3) Öğrencilerin otantik öğrenme deneyimleri üzerine erken STEM eğitiminin temel rolü. Bu bulgular, STEM eğitiminin, erken dereceli yaşlardaki sınıflarda otantik öğrenme deneyimlerinde nasıl bir rol oynadığına dair bilgi vermektedir.

Anahtar Kelimeler: Erken STEM eğitimi, otantik öğrenme deneyimi, etnografik durum çalışması

CHAPTER 1

INTRODUCTION

In todays' world that is integrated with globalization; leadership in economic success, technological development and workforce diversity is getting more and more important. Along with these developments and resources in the world, the competition for innovation among countries is increasing. Along with all these industrial and technological developments, most of the countries need some reforms in their educational policies. Countries have made different plans for raising quality of education to all sectors of the society, as well as raising qualifications in education and putting different programs into practice. In other words, the complexities of today's world require all people to be equipped with a new set of core knowledge and skills to solve difficult problems, gather and evaluate evidence, that is to adapt to real life conditions by developing their 21st century skills (creativity, critical thinking, problem solving etc.). Accordingly, this requirement has led the countries to give importance in science, innovation and engineering.

At this point, in the face of these changes, needs and skills; primarily the teaching and dissemination of engineering education in primary and secondary schools has become a matter of importance [1]. Along with the debate on engineering education and its implementation in schools, it was thought that engineering would create a very good environment for mathematics, science and technology education, so a trend called STEM (Science, Technology, Engineering and Mathematics) has become popular [2].

STEM (Science, Technology, Engineering, and Mathematichs) education is an educational approach involving interdisciplinary teaching of science, technology, engineering and mathematics, and encompasses all the process of K-12 education [3]. STEM education is also very important in terms of enabling the theoretical knowledge to be transformed into practice and product. Namely; new age expects individuals to

become producers and this requires that individuals have sufficient knowledge in various areas to demonstrate their productivity. However; problem situations in the 21st century show a rather complex and dynamic structure and therefore, it is difficult to gain expertise in different areas within this complex and ever-changing world [4] and individuals need to work collaboratively with from different disciplines. At this point, STEM education is very important in today's information and communication age in terms of enabling people from different disciplines to work together [5], [6], [7], [8]. That is to say, children are expected to gain an interdisciplinary point of view from their early ages and to provide information in a concrete way.

Along with these reasons, we need an educational culture that gives responsibility to students, leads them to think and inquire, and also equips them with technological information like computer programming from young age. Without creating such an educational culture, it will not be possible to compete in the global economic order, which will have an even more challenging pace in the 21st century. Therefore, students should be educated to be able to create products using their scientific, technological, mathematical and engineering skills. That is why; it is necessary to develop educational policies and programs in consideration of these needs of the country.

From these reasons, STEM education for students has been started in many countries around the world in order to sustain economic development and to adapt the real life conditions. In our country it is also important to start the integration of STEM education into our education system since students take less scores than students from other countries in mathematics and science disciplines in international exams like Program for International Student Assessment (PISA) [9]. In addition, STEM education has an important place to close the gap between theoretical knowledge and practice [10] and influence on meeting individuals' future needs. Namely, STEM education aims to provide four disciplines to students as science, technology, engineering and mathematics which are used in many areas of daily life [11], [12]. So, since it has developed both the ability of students to produce a product and to handle events from different perspectives, students will be more experienced and not only science literate, but also conscious individuals in the fields of technology, mathematics and engineering [12], [13]. For all of these reasons and needs, STEM was integrated into our science curriculum as science and engineering implementations in the light of a solution-

oriented approach to the information-oriented authentic problems in the process-product unity [2].

Furthermore, STEM education also provides real-world experiences by engaging students in an active and authentic learning environment. Authentic learning provides to apply knowledge in real-life context and situations and engages students in some kind of hands-on or experiential learning by providing opportunity to learn by themselves in an authentic environment [14], [15].

Authentic learning also focuses on real-world problems [16] and students are actively involved and participate the entire process of authentic learning [17]. That is authentic learning is learning by doing and develops the students' critical thinking skills [18]. Also according to Milson [19], it is a process of asking meaningful questions, getting information, and developing multiple solutions as in STEM education. Namely, students gather data and analyse them by using their observation or experimental results and in this way, it is expected that new information will be generated by using existing knowledge and scientific methods. From this perspective, emphasis on STEM education, especially at primary level, also increases since it provides real-world experiences by engaging students in an active and authentic environment.

In early childhood education, STEM can be beneficial and effective because, students in early grades have great curiosity about the world and situations around them and also they are eager, curious, and ready to learn. Children who engage in STEM education from early age also have positive attitudes toward scientific and engineering practices [20], [21] and this can also affect their later achievement and choice of STEM careers [22], [23]. Students in early grades have capacity to learn on their own but they need adult guidance, so STEM education provides these possibilities in an authentic environment. In authentic learning, students' sense of self-efficacy and also achievement in content knowledge improve since they learn the concepts by considering multiple perspectives in real life situations [15]. That means; students make connections with their prior knowledge and also learn the new information deeply and in this manner, meaningful learning takes place.

Research also shows that children should have STEM learning experience from early ages because STEM education develops scientific literacy of students which is necessary for today's life conditions [1], [12], [24], [25], [46]. The National Science

Teachers Association (NSTA) [24] also states that "…learning science and engineering practices in the early years can foster children's curiosity and enjoyment in exploring the world around them and lay the foundation for a progression of science learning in K–12 settings and throughout their entire lives (p.1) [24]". In this way, students' interest, experiences and learnings can be improved in a natural and purposeful manner.

According to the National Science Education Standards [26], if young people are able to keep up with today's living conditions, they can overcome future problems related to science and technology. In other words, if students experience to handle todays' authentic problems, they will be even more successful in the future by using their 21st century skills (eg. critical thinking or problem solving). At this point, consistency between STEM and early chilhood education can provide an integrated approach that improves children's authentic learning experiences with real life related problems [27].

In addition, through integration of STEM into our education system, it gains higher importance to understand what is STEM and how it is implemented into classroom. That is why; studies on this issue have important place in national base and also more studies are needed.

At this point, this qualitative ethnographic case study provides insights on implementation of STEM education on the learning environment of a group of students who are at early grades. Also, this study has an important place since it informs about evaluation and monitoring STEM education in classroom as well as students' authentic learning experiences at early grades.

1.1 Literature Review

This part consists of the research conducted on STEM education, authentic learning experiences and also interrelation among them. These studies are organized under three headings; (a) STEM education, (b) Early STEM education and (c) authentic learning experiences. The first section, STEM education, explains the place, implementation and effectiveness of STEM education by considering curriculum, challenges and views. In the second section, Early STEM education and why STEM education is important especially in early grades is analyzed criticially. The last section, authentic learning experiences, synthesizes what is the meaning of authentic learning, what is the place in STEM education, what is the role of authentic learning experiences in STEM education and how they are interrelated with each other.

1.1.1 STEM Education

In today's education system, STEM education is constantly being discussed and great emphasis is given on this area globally. Most of the countries focus on their K-12 education to increase students' interest on STEM subjects and also to engage them into STEM careers [27], [28], [29]. But in order to have an advance on this area, it should be clarified what STEM education actually means. According to Brown [30], STEM education spreads over a wide area and consists of ambiguous variables and that is why, there are different definitions on this issue [30]. STEM is an acronym for science, technology, engineering, and mathematics and in some studies this acronym is used as the definition of STEM education. In other words, STEM is identified as separate disciplines and they are taught in an unrelated manner [24], [25], [26]. Otherwise, STEM is defined as an educational program that spreads from elementary to postgraduate level, also includes adult education [31] as an integrative approach to curriculum and instruction [35]. In similar, STEM is stated as an integrated approach that improves motivation and achievement of students in science and [32] by focusing on real world and authentic problems to solve with different perspectives [33]. In Lantz study [34], STEM education was described as an interdisciplinary approach that students apply science, technology, engineering, and mathematics in a context that makes connections between various aspects of their lives. In the line with the literature, it can be summarized that STEM is an interdisciplinary approach that is used in different grade levels (from kindergarten to postgraduation) by integrating four disciplines with each other to solve an authentic and real world problem. Beyond this, STEM provides opportunities to point out the 21st century skills which are necessary to survive in our future life.

In the literature, research conducted in the field of STEM education is spreading over a wide range. The following part provides further information on the studies on STEM implementation, STEM careers, integration of STEM etc. and presents analysis of them.

According to Meyrick [37], learning should be supported by the activities that focuses on students' engagement and knowledge; synthesis, problem solving and critical thinking skills in order to improve deep learning. In 2006, it was seen that some courses (technical drawing, engineering drawing, architectural drawing) which include design processes have a positive effect on students' achievement in standardized test scores [36]. Moreover, emprical studies concluded that if learning activities encourage students

to practice integrated skills in dealing with realworld problems, deeper and more meaningful learning can take place [38]. Therefore, school programs have adopted according to increase students' achievement, engagement, motivation and interest. The report Tapping America's Potential [37] showed that students' interest on engineering careers and attitudes towards STEM studies decreased and therefore, integrating engineering into instructional curriculum has gained importance. In this way, curriculum can be connected with real world and provides authentic possibilities to adress the needs of students' learning and solving problems.

Rockland and colleagues [39] explained that: "Science can be viewed as proposing explanations for questions about the natural world, whereas engineering proposes solutions for problems of human adaptation to the real world (p.54) [39]"

From this point of view, each discipline provides learning from different perspective and accordingly, instructional strategies should be designed by considering concepts of science, mathematics, engineering and mathematics within integrated environment [39]. In recent years, importance on design processes in education system is given and it is ensured that the learners can transform their knowledge into a concrete structure. In this manner, an education that addresses the applicable direction of knowledge may be more beneficial and productive [13]. In addition, Honey and colleagues [41] advocate that: "Integrated approach to STEM education, especially in primary level, with real-world problems, can increase the interest, success and motivation of students; and ultimately help to increase the number of students making careers in STEM fields (p.22) [41]".

From this perspective, in another study, engineering design process have been developed for primary and secondary school students. Little, Poth, Gilbert & Barger [42] have adopted engineering design process steps into primary education as "plan, design, control and share". Corbett and Coriell [43] have also staged for junior high school students as "defining the problem, identifying the research problem, brainstorming for solving, choosing a solution, creating and developing models, testing and evaluating the model, developing and redesigning". In the similar way, engineering design process was also created as "'ask, imagine, plan, create and develop" [44]. From these studies, it can be understood that there is a need in engineering design process in education system since there is a lack on this issue in our curriculum. Also, as can be understood from design processes mentioned above; creation, discovery, problem solving and inquiry-based learning have a great place in STEM integration in terms of

working in teams, testing design, planning and implementing the whole process to find a solution to problems.

There are also various research [12], [46], [47], [22], [23] that have been carried out on the effects of the developed STEM programs on students' scientific process skills, learning, creativity, scientific and innovation literacy, attitudes, academic achievement and etc. Yamak, Bulut and Dündar [45] conducted their study with 5th grade students to investigate the effect of STEM activities on students' scientific process skills and it was determined that STEM activities developed students' scientific process skills and their attitudes toward science in a positive way. Meyrick [37] also investigated the effect of STEM implementation on students' reasoning skills, critical thinking skills, creativity, innovation and concluded that STEM provides equity among all students who have different backgrounds. Beyond this, only implementation of STEM is not enough to supply these skills as well as scientific and innovation literacy skills [46], [47]. That is, teaching implementation process or structuring instructions and also learning environment are important. Also, more controlled learning environment [47] and programs that combine four disciplines are more benefical to improve these skills [48]. In the line with the literature, it can be concluded that designing and investigating the STEM implementation process has significant role on students' career awareness, establishing relations with real life, engagement with subject matter and also sense of self-efficacy. That is why; reserachers continue to develop and implement STEM programs to investigate these issues and this ethnographic case study also investigates the implementation process of STEM education in a school setting and finds answers about in what ways it has a role on students.

1.1.2 STEM Education in Primary Level

Primary education has important place on students' future life since it provides a foundation in learning and understanding the world as well as early childhood education. Children who are at any age are more curious about their environment and they try to find answers for the questions in their minds. At this point, with education as early as possible, children can develop positive attitudes towards disciplines, they can find possible answers for questions and they can also improve their skills with true instructions. In this manner, STEM education plays an important role on students' learning and skills in science, technology, engineering and mathematics. Therefore, if

STEM education is given to students from early years, for example from pre-kindergarten level, its effectiveness and benefits can be also increased.

Actually, children in primary grades are also willing to design or invent [49]. Thus, they should be encouraged to ask questions, to make investigations, to produce some materials and to find some solutions to problems which encountered in daily life. Although both primary education and STEM education stated as an important factors that effect students' future life, there are little research were done by combining these two [1]. In order to provide quality education, students should be gained experiences on technology and engineering as well as science and mathematics [50], [52]. For instance, Sullivan and Bers [50] conducted a study on integrating technology and engineering disciplines with robotics in elementary level. Because they stated that robotics is a powerful way to engage students especially in early grades in technology and mathematics. In other words, our children need to take theoretical knowledge revealed by sciences such as physics, chemistry, biology and mathematics in primary education on basic level, and innovate to add value to life by blending technology and engineering [47], [49].

Sanders [12] states that in order to enhance scientific literacy and to increase students' motivation and interest, students should experience STEM activities as early as possible. Also, engaging students in STEM activities affects their later career choices [1], [12]. In this manner, researchers [12], [51], [57], [58] suggest that implementation of STEM improves the choices of future STEM careers and therefore recognizing these careers and designing their products by getting into their roles, especially at an early age, have a very important place. Besides this, some research also were done with undergraduate students to define when they chose their professions [53], [54] and it was concluded that the best time to build awareness and interest in STEM fields is early school years.

In addition, implementation of STEM in early grades is a significant issue, because if it is applied effectively, the aforementioned results can be reached. At this point, there are some research that design STEM activities for early grade students. One of them is conducted by Tippett and Milford [1] with design based research. According to this perspective; if at least two of the four disciplines are integrated, it can be considered as STEM activity. Also, the designed curriculum should increase students' interests and should help them to succeed in science besides teaching only scientific knowledge [55],

[56]. According to Balat and Günşen [49], there are three important components for children who are early grades to gain skills on STEM: a well-organized training program, teacher training and family unit. That is, if a curriculum involving activities appropriate for the STEM approach to the preschool child is administered by well-trained pre-school teachers and also supported by the family, pre-school children can effectively improve their skills.

Moreover, in order to integrate STEM education into our education system, some research and projects have been done. Yıldırım and Altun [64] focused on the integration of STEM into the lectures and they experimentally compared STEM education and our education system. The results show that STEM education is effective in improving students' achievement. Beyond these, in some universities, STEM centers or laboratories were established [2], [66] and researches are conducted with teachers or preservice teachers in the implementation of STEM activities [65]. But, little attention was given on early childhood STEM education. According to the reports on STEM education [12], [66], [67], STEM should be partly integrated in our education system for all grades.

As a result of these preliminary studies and investigations, in Turkey, STEM emerged as a new approach in our education system and it was partly integrated into our science curriculum as science and engineering applications from 4^{th} to 8^{th} grades by the Ministry of National Education [59]. Also, new changes are foreseen on integrating STEM into curriculum as being part of the whole process. This has caused many changes in science education such as teaching and learning strategies, classroom environment, assessments etc. Also this change has an important place to close the gap between theoretical knowledge and practical knowledge. If children are given the chance to discover the world and the opportunities to solve problems by using their own independent judgments, skills such as creativity, critical thinking, problem solving, which are called STEM skills, can be also developed [49]. From this perspective, some studies were done for the integration of STEM into curriculum, but most of them were conducted with secondary or upper grade levels [11], [13], [28], [45]. In addition, although there are many studies on how effective science education should be, little part of that includes how science sould be thought in primary education [60], [61], [62]. However, children start to learn concepts of science, technology, engineering and mathematics in early years and in this process, there is a need for necessary

environment and activities that children can apply and construct these concepts [49]. According to Clements and Sarama [67], STEM instruction in early grades "…should follow research-based learning trajectories that include three components: a goal, a developmental progression, and instructional activities [67, p.75]".

In the line with the literature, students should be engaged in STEM from earliest years of life and in this process, an education should be provided in an integrated and authentic manner as occured in real life. From this perspective, early STEM Program was developed within STEM: Integrated Teaching Project framework. In this etnographic case study, in the light of the program, what integrated and curricular design looks like and also implementation in early grades were presented.

Early STEM: Integrated Teaching Project

STEM: Integrated Teaching Project was developed for science and mathematics teachers who are in secondary and high school levels. Based on this project, a program called as "Early STEM" was developed for K-4 students by BAUSTEM Center (Bahcesehir University STEM Center). The content of the program were developed according to integrated teaching project framework which is based on four STEM disciplines in themes. In other words, each theme of the early STEM Program was centered on the one STEM discipline (ie. My World of Imagination theme focused on the mathematics discipline while My Green World theme focused on science discipline). The project also implemented 10 schools in six different cities of Turkey. In the scope of the program, one lesson hour per week was assigned in school curriculum. That is, every week STEM lessons were held by classroom and preschool teachers during one lesson. In the light of four themes based on STEM disciplines (science, technology, engineering and mathematics), the program spreads over eight month period and each theme lasts 8 weeks.

The themes which are developed to transfer theoretical and pedagogical content knowledge to practical teaching skills are related to disciplines of Science, Technology, Engineering and Mathematics (STEM): My Green World, My Computational World, My World of Machines and My world of Imagination (see Figure 1.1) in order.

Figure 1.1 The early STEM program framework (Taken from: p.5 [4])

The early STEM program was constructed according to the plans prepared by selected classroom and preschool teachers with the guidance of the two academicans during workshops. These workshops were conducted and the themes and Authentic Problem for Knowledge Society (APKS) were also developed by BAUSTEM Center (Bahcesehir University STEM Center). APKS is one of the most original parts of the developed program and it can be defined as a problem that is information-oriented, open-ended, no single absolute answer, and therefore can have more than one solution. In order to give certain directions to students and clarify APKS; each APKS is presented with certain limitations such as the budget allocated for materials or products.

One or two classroom and preschool teachers from the schools, in which the early STEM program was to be applied, participated in the workshops. These teachers developed the contents of the lesson plans in the light of themes and problem situations according to their class level and then BAUSTEM Center created lesson plans for the program for each theme by making final arrangements in the line with the ideas of the teachers. At the end, a guidance book for each theme was developed for the teachers who did not attend the early STEM workshops.

These lesson plans was developed according to STEM cycline (which is mentioned in chapter 2) which is developed by focusing on the common points of scientific process methods rather than differences [4].

In the implementation process, each theme lasted eight weeks and each week one phase of the STEM Cycline model was applied in the order that: APKS, Fact Finding, Ideation, Product Development, Elaboration/Product Development, Refinement, Disseminate and Reflect. In the last week of each theme (the phase of reflect), the designed products were presented.

1.1.3 Authentic Learning Experiences

Learning should be integrated into real-life conditions and the transfer of information to be learned should be also ensured to make learning meaningful. The education system also aims to acquire the knowledge and skills that students can use in their personal or professional lives. At this point, authentic learning has an important role since it is related with real life [16]. In other words, authentic learning encouraged students to produce useful products that are used in real-life context by using all senses that enhance the learning experience. In authentic learning, real world problems are tried to be solved [16] and students are actively involved during this learning process by interacting, manipulating, exploring or collaborating [17], [18] . Therefore, it becomes effective to improve students' 21st century skills such as imagination, creativity, problem solving as stated in STEM education implementations [12], [13]. It means that STEM education provides real-world experiences by engaging students in an active and authentic environment and so it has important place in authentic learning process. According to The National Science Teachers Association (NSTA), instructional strategies should be related to the learning techniques [24] and so science programs should include hands-on and real life experiences that ensure cooperation [40]. From this perspective, while construction of the learning individually is important to make learning permanent [68], working collaboratively and sharing knowledge with the community or group members improve students' ability to deal with real life complex learning environment [69].

In this manner, Herrington and Oliver [69] observed students and interviewed with them to determine their views on authentic learning environment and they stated that authentic learning environment ensures the collaborative learning. Also, in order to design an instructional framework for authentic learning environment they determine some critical characteristics (authentic context, authentic activities, reflection, articulation etc.), then applied them by creating a multimedia program and the most interesting finding of the study was that collaboration had a significant role on this learning model. Ayar and Yalvaç [14] stated that authenticity is one of the criteria that should be taken into account while designing innovative learning environment. That is, authenticity is related with the routines which include laboratory activities, modelling, writing research report etc. and they are contextual and related to the environment [14]. Marshall [70] also argued that learning environments for a quality education should

improve students' skills such as creative thinking, problem solving, innovation and so on. At this point, Erdoğan and Stuessy [71] identified some components of STEM schools and they created a conceptual framework of effective learning environment. According to these studies, authenticity and STEM education presents an effective learning environment by focusing on goals and process with hands-on activities, discussions and reflections.

Moreover, Braund and Reiss [72] studied on out of school learning and they stated that authentic learning provides more real life experiences that scientists or engineers do. Namely, gaining authentic experiences have effect on students' imagination, problem solving skills, thoughts, designing and building skills that they will use in their future professional life. These are the skills that each student should have. Aina, Aboyeji and Aboyeji [73] investigated pre-service teachers' authentic learning experiences and they found that the reason why they can not be achieve at an adequate level at work is that they can not relate theory and practice. That is, if individuals do not relate the classroom experiences with real-life situations, they cannot be effective at their life. At this point, STEM education has an important role on transferring the theoretical knowledge into practice in real-world context, so students can gain authentic learning experiences with STEM education. In one study [74], the implementation of authentic learning through STEM education approach was searched and the effects on students' learning under metacognitive levels were investigated. Thompson-Krug [40] also studied on the effects of authetic learning on female students' perceptions of science and STEM careers. As a result of these studies, they were found that authentic learning experiences have positive effects on both learning and STEM disciplines. Therefore, some researchers also studied on designing some instructional strategies and guidance for the implementation of authentic learning [16], [17], [69] and some criteria were determined such as relevance with real-life problems, having open-ended solutions, sustained investigation, collaboration etc. Besides this, Burton [75] also suggested some variables to determine authenticity: doing or dealing with real world situations, working with tools used in real-life, working under real-life conditions. STEM education has an important influence on achieving these criteria since it was defined as "knowledge, skills and beliefs which are collaboratively constructed [by students and teachers] at the intersection of more than one STEM subject area (p.75) [3]" and focuses on interdisciplinary approach to motivate learners to solve real-world problems with integrated STEM knowledge and skills [76].

In the line with the literature, it can be seen that there is a need to support more diverse strategies or programs that encourage, support and motivate students by engaging students with authentic issues and problems with improved skills. At this point, STEM education provides authentic experiences that improve students' 21st century skills and prepare them for real-life. Therefore, authentic learning experiences through STEM education provide insights on effective learning environment, instructional process and also knowledge will be useful in real-life. However, there were few researches dealing with the relation of authentic learning and STEM education especially in early grades. From this perspective, this ethnographic case study investigated the authentic learning experiences of students through early STEM lessons and it focused on what were their roles, responsibilities and interactions.

1.2 Objective of the Thesis

The purpose of this ethnographic case study was to investigate the students' authentic learning experiences through early STEM lessons based on the framework of Integrated Teaching Project. In accordance with this aim, there are three research questions that guide this study as follows:

1) How do students perform authentic learning experiences in Early STEM lessons?

2) In what ways do students engage in Early STEM lessons?

3) In what ways authentic learning is integrated in Early STEM lessons?

1.3 Original Contribution

Recent national initiatives in education have focused on improving access for young people in STEM careers [66], [3]. It is also important to make efforts to attract more students to scientific and technological innovations, since students can then be guided to the relevant professions. So, in ırder to improve knowledge level of society, multi disciplinary education with high quality is needed in science, technology, engineering and mathematics [77], [78]. Reaching this aim can be poosible with skilled, responsible and inspired young students and the number of graduates in the field of science and technology should be increased. At the point of increasing it, STEM education has crucial role in order to drive critical thinking and innovation in today's society [18]. In other words, STEM education provides an insight on students to be more innovative with 21st century skills.

In this context, there is a need to integrate STEM into the education system and in 2017, STEM has taken its place in the science curriculum [59]. Beyond this in 2018, it is concieved that new changes will be made at the point of integrating STEM into science curriculum from 4^{th} to 8^{th} grade. But, adapting and implementing the school curricula are the trouble some issue. For that reason, emphasis has also given on how STEM is implemented in the classroom and reserachers conduct some studies on integration of STEM into curriculum at multiple levels. Carr and Strobel [79] studied on university level curriculum designed for pre-service and inservice teachers in order to guide them in teaching STEM. Literature also includes some studies about the integration of STEM within K-12 education. However, there is a need on implementing STEM in elementary level [20], [21], [50], [57] and also these studies are inadequate to give specific details on how integrated curriculum is designed and implemented. At this point, this ethnographic study presents an example for implementation of STEM in early grades within the scope of Early STEM Program through observations and interviews.

In addition, this present study focused on authentic learning experiences of students through the early STEM program. Rule [80] reviewed the literature and determined four components that describe authentic learning and they were as follows: "1) the activity involves real-world problems that mimic the work of professionals in the discipline with presentation of findings to audiences beyond the classroom; 2) open-ended inquiry, thinking skills, and metacognition are addressed; 3) students engage in discourse and social learning in a community of learners; and 4) students are empowered through choice to direct their own learning in relevant project work (p.2) [80]"

Lombardi [81] also determined 10 design elements which are: "real-life relevance, an ill-defined problem, sustained investigation, multiple sources and perspectives, collaboration, reflection, an interdisciplinary perspective, integrated assessment, polished products, multiple interpretations and outcomes (p. 3-4) [81]". Early STEM program that is developed under the scope of STEM: Integrated Teaching Project meets these elements and this study presented a framework for the combination of authenticity and early STEM education (detail information is in chapter 2). From this perspective, this study focused on the quality of process that allows students to become more skilled and it may have importance to pursue learning opportunities that takes students' interests with real-life processes from early ages.

CHAPTER 2

FRAMEWORK OF THE STUDY

In qualitative research, research design starts with a philosophical assumption that guides the research process; inform and shape to conduct study [82]. Savin-Baden and Major [83] stated that while analyzing and interpreting the data, framework guides the researcher for research subject. From this point, this chapter explores the theoretical and conceptual frameworks to recognize the reliability of the study.

2.1 Theoretical Framework

In qualitative studies, researchers choose a theoretical perspective for designing and conducting the studies and this perspective directs the researcher through the study while collecting data, examining information and also interpreting findings [82]. At this glance, this qualitative ethnographic case study was guided by interpretivism and socio-construstivism as theoretical framework.

Interpretivism is a qualitative perspective that researcher interprets the data through subjective viewpoint [82], [84]. Besides this, through interpretivist lens, the world is perceived in different ways by individuals with different experiences and perspectives. For this reason, researchers who have interpretivist approach are conducting research in the light of their own perspectives within the scope of research questions and purpose [82], [83]. Therefore, meaningful results are obtained, at least without being reduced, from the data obtained from individuals by various methods within the study. In other words; in order to be informed about a group or individuals, various methods need to be used [82], [83], [84]. In this way, a researcher can obtain and interpret the information belonging to that group in a versatile way using a combination of methods such as field notes, observation, portfolio analysis and interviews. At this point, interpretivism was the best suitable approach for this ethnographic case study, since the views of the

participants, their communications within the group and the words they used during the process or the interviews enable us to gain an effective idea about the engagement and experiences of the students in early STEM lessons. Besides this, each individual's prior knowledge or level of readiness is not the same, and all of them can be achieved by the individual's experiences that are perceived in different ways [84], [85]. Thereby, this study was aimed to investigate the students' authentic learning experiences through behaviours, interactions, sharing knowledge, taking responsibility etc. in early STEM lessons and interpretivist perspective provides a way to analyze these actions. Actually, interpretivism focuses on students' acquired knowledge and skills in an active manner [82]. That is, intepretivism advocates that when students are practically directed to solve real-life problems, effective learning takes place [82], [83]. Under these premises, students should be encouraged to reach their own results by trial and error methods and this present study focused on these issues. So interpretivism is one of the best appropriate approaches for this study.

In addition to the interpretivism, another theoretical framework that guide the researcher to interpret the collected data for this ethnographic case study is socio-constructivism. In this worldview, individuals try to understand the world they live in and work and they try to clarify subjective meanings of their experiences on the events they encounter [82], [83]. These meanings are also constructed socially, namely, by interacting and sharing knowledge and skills with other people. That is why; researchers focus on the process of interactions among participants in socio-constructivist perspective. From this point of view, the research questions of this ethnographic case study depends on individuals' actions and their interactions during early STEM lessons. In other words, knowledge and understanding of early STEM lessons were gained from experiences in classroom environment; so this worldview (socio-constructivism) informs the study results.

To sum up; in the light of interpretivism, participants' views and experiences were studied and interpreted through their views and experiences and socio-constructivist approach guided this present study to understand the implementation process of early STEM lessons and engagement of students into these lessons.

2.2 Conceptual Framework

As noted before, frameworks are used to guide interpretations of research results and so researchers want to use a conceptual or theoretical frame. In this manner, these frameworks also ensure a logical structure for determining and interpreting themes and concepts which are derived from research results [83]. That is why; a conceptual framework which is derived from related concepts helps researchers to realize the key points and outcomes for the study. Besides this, logical structure of the meanings under conceptual framework guides the development of the study since the key concepts were defined, clarified and also associated with each other. From this perspective, Authenticity Model and STEM Learning Cycline guided this ethnographic case study as conceptual frameworks.

2.2.1 Authenticity Model

Engineering education researchers Strobel, Wang, Weber and Dyehouse [86] reviewed the literature on authenticity and they found that "authenticity affects the potential complexity of the task, the multiplicity of possible solutions and the potential disciplinary ideas to be taught with the task (p.147) [86]". According to literature analysis, they created a framework which is called "Authenticity Model" and this model presents four types of authenticity; context authenticity, task authenticity, impact authenticity, personal/value authenticity; that is aimed to relate abstract ideas with real-life contexts [86]. In this ethnographic case study, it was also intended to investigate and analyze the students' authentic learning experiences during Early STEM lessons. Also, data were collected from observations during the implementation process of My World of Imagination theme and this theme based on mathematics discipline which includes abstract concepts. Thus, Authenticity Model is a suitable conceptual framework for this present study to analyze the research results.

According to Authenticity Model, the types of authenticity were divided into two dimensions which are external and personal. The descriptions and curricula features of each type of authenticity were presented in Table 2.1 as follows:

Table 2.1 Types of authenticity described by Strobel et al. (Taken from: [86])

Types of Authenticity	**Description/Key Definitions**	**Curricula Features**
Context Authenticity	1. Contains a real-world professional environment 2. Provides everyday experience 3. Resemble social challenges or social interactions 4. Align school and professional outcomes	1.Provide input from diverse stakeholders 2. Be a complex problems solving context and interdisciplinary context 3. Provide situations of collaboration, access to tools and resources and ownership
Task Authenticity	1. Students are engaged in tasks similar to professionals 2. Reflect or develop professional skills for students 3.Challenge students in decision-making in practical context	1. Contain ill-structured problems, no pre-specifications 2. Contain open-ended creative activities 3. Promote disciplined inquiry 4. Ask students to interpret ambiguous data
Impact Authenticity	1. Actions in cultural practices 2. Social events, issues or impact 3. Students' role as effective citizens 4. Students as collaborators of industry	1. Professional community standards in relative area 2. Project results influence people outside of school 3. Minorities' experiences in the role of engineers or scientists
Personal/Value Authenticity	1.Produce knowledge with values in students' lives and studies beyond simply proving their competence 2. Integrate everyday life experience, personal interests, professional target and cultural values 3. Develop a sense of identity and sense of confidence	1. Problematizing the subject matter 2. Perceive relations between the practices and the use of value in them 3. Pursue personal goals and have personal choice 4. Be engaged in personal construction of new knowledge in learning task-environments

Context authenticity helps to experience real-life situations in a scientific way and also in a classroom environment [86]. That is, it provides answers for the question of "What makes a context authentic?" For example, since it is related with real-life experiences, students try to design a product which can be used in daily life to solve a problem. From this perspective, this ethnographic case study also aimed to observe and investigate the students' production process during early STEM lessons under the themes which are related with real-world situations.

Task authenticity takes part when students are in a role of a profession in the activities they perform. Authentic tasks were also defined as "challenge students in decision-making in practical contexts (p.147) [86]". In this manner, students' problem solving skills are developed and they become conscious of the duties and responsibilities of a profession by engaging before they started to their professional life. In this present study, students had also some role and responsibilities of professions such as engineer, physicist, environmental expert, landscape architect etc. related to theme subject.

Impact authenticity is about the things that students do are an effect in their real life. In other words, this type of authenticity tries to find answer of "What impacts can an authentic experience deliver out of school? (p.147) [86]" Therefore, it enables students to practice what they learn in their classes and the transfer of this learning are supplied into real-life. In this present study, students also try to design and invent some products in the way of being effective in real life setting.

Personal/Value Authenticity is concerned with the extent to which the studies carried out have affected the lives of the students and it develops students' own self-learning skills. It is also important that students are active in the learning process [86]. For this authenticity type an example is given like that "the collect[ion of] data on the use of water in [a student's] household throughout the year [to] investigate possible ways to reduce consumption (p.149) [86]" In the same manner, in this present study, students also tried to solve real-life problems and they made some research with their group members and also ponder or share their findings and products with the teachers, their friends, family members at the end of the each theme.

From these perspectives, students' authentic learning experiences were investigated based on this "Authenticity Model" and this model was used as conceptual framework to analyze the research data. According to descriptions of the authenticity types, field

notes from observation of early STEM lessons and transcripts of interviews with students and classroom teacher were analyzed.

2.2.2 STEM Learning Cycline

STEM Learning Cycline; STEM Learning Cycle and Line (Figure 2.1) were also used as another conceptual framework to analyze the research data. This cycline is a learning cycle that was created as a model for the purpose of modeling the STEM: Integrated Teaching Framework [4], [87] in teaching and learning process. It is also divided into two parts as cognitive process and social product. It was developed by focusing on the commonalities of the methods of scientific inquiry, computational thinking, project-based learning, and mathematical modeling as cognitive process by centering each STEM discipline separately [86], [87]. Besides this, Early STEM lessons was developed in the line with 5E instructional model [89], and the STEM Cycline guides the teachers how to plan the cognitive process and social product sections in their lessons. In this manner, each week one phase of this model is applied.

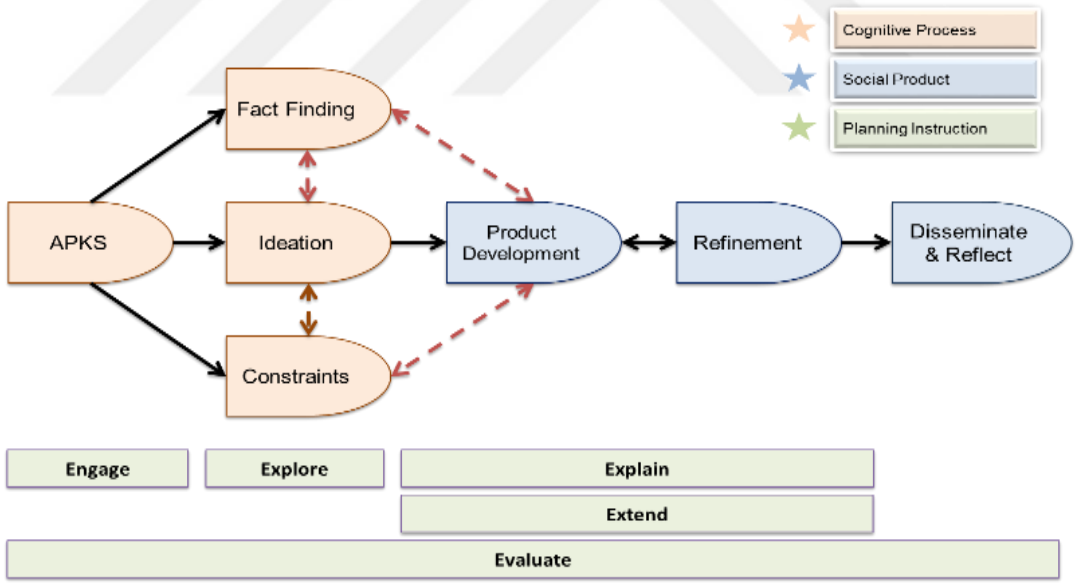

Figure 2.1 STEM learning cycline (Integrated Teaching Project STEM Lesson Plan Model) (Taken from; p.4 [4])

At the beginning of the STEM Cycline Model, there was the Authentic Problem of Knowledge Society (APKS) which is based on the interests of students and teachers in the 21st century. Then this cycline continued with the "Fact Finding" and "Ideation" with constraints. After the ideas were formed, the students went through product development phase using selected materials. The eight-week process for each theme of early STEM program was over with an expo-week in order to present their products to their families and teachers that what they did during this process (Each phase was explained in detail in chapter 3).

In the light of these manners, a framework was developed based on the combination of these two models: Authenticity Model and STEM Learning Cycline. According to the connections between these two models, determined framework guided the researcher for the observation field notes and also interviews that were taken for this ethnographic case study (the combination of the models will be explained in detail in chapter 3).

CHAPTER 3

METHODOLOGY

In qualitative research, events and themes develop and change throughout the data collection and analysis process in which researchers use an inductive viewpoint [82]. In this manner, this present study was conducted to investigate students' authentic learning experiences in early STEM lessons through observations and interviews and therefore, qualitative research is a suitable way to analyze the collected data. In other words, qualitative research focuses on the "human" side of an issue, that is, individuals' thoughts, views, experiences are important in terms of the research results. In this type of research, researchers are a part of research process and their perspectives are also important [83]. From this perspective, this present study also focused on students' authentic experiences and engagement in early STEM lessons and the results were evaluated according to students' construction of the meaning. That is why; participants' views, actions and experiences have fundamental place for the research results. Parallel with this approach, this study provided information about how early STEM lessons were implemented and how students experienced authentic learning in a detailed way.

In this chapter, the descriptions of the methodology and research design for this qualitative ethnographic case study were addressed. The methods used to collect and analyze the data transcripts of interviews and field works included eight classroom observations, thirteen interviews with students, and a single interview with teacher. The methods were important to the emergence of the themes that represented this qualitative ethnographic case study of early STEM lessons under the following research questions:

1) How do students perform authentic learning experiences in Early STEM lessons?

2) In what ways do students engage in Early STEM lessons?

3) In what ways authentic learning is integrated in Early STEM lessons?

3.1 Research Design

Qualitative Ethnographic Case Study Design

In this present study, qualitative ethnographic case study design which is the integration of ethnography and case study was used. This type of research design as occurs in each methodological design ensures guidance for researchers while conducting a scientific study [82], [83].

Ethnography was defined as a philosophical study which is the existence of individuals in their own cultural environment [83]. Creswell [82] also described the ethnography as a good opportunity to gain knowledge about individuals within a cultural setting. Also, ethnographic studies are based on long-term observations and interviews of individuals in a culture or group. Therefore ethnography allows us to reach the results that we cannot obtain with experimental methods about the individuals' behavior, actions or experiences in a deep way. In this context, Angers and Machtmes [104] conducted an ethnographic case study to explore the beliefs, context factors and practices of teachers through observations in classroom that lasted 25 days and interviews. So, ethnographic characteristics of this study were the interpretation of culture sharing group. In the same manner, in this present study, the participants were 4^{th} grade students who are all in the same class and the same classroom teacher teaches them, and they were selected for the reason that they represent a group of individuals who work together to solve a real-life based problem by reaching necessary information and producing ideas in early STEM lessons. In addition, the early STEM lessons were conducted in a classroom where is the natural setting and the students were also involved in their natural environment. That is, the culture for this study was consisted of a group of students who attend early STEM lessons during one year and one classroom teacher in their natural environment as stated in the study of Angers and Machtmes [104]. For these reasons, ethnography was the best suitable research design for this study to investigate students' authentic learning experiences within the events occurs in their natural setting during early STEM courses. On the other hand, ethnography requires to be part of a culture and the researcher were involved in the preparation and implementation process of early STEM program and so the researcher also became a member of that culture.

Furthermore, case study was another research design for this present study. According to Yin [88], case study is a method that allows the researcher to conduct an in-depth research on real-life situations and also to explore events, people or groups. Also, it presents an opportunity to analyze the events or individuals' actions in a deeper manner through observations and interviews in a natural setting [82], [83]. "An ethnographic case study is defined as prolonged observations over time in a natural setting within a bounded system (p.777) []" In this present study, observations were done over a prolonged period of time in a single classroom setting in one of the school where early STEM program implemented. That is, it was studied on the culture of a particular social group by focusing on the early STEM program.

From these perspectives, these two research designs (ethnography and case study) were used to describe students' authentic learning experiences in early STEM lessons and also during this process, it was aimed to be explore how students engaged in STEM lessons and how they reacted with each other in an authentic context. In other words, ethnography provided an opportunity to analyze the students as a member of the group while case study ensured a framework on how early STEM lessons were implemented in a classroom setting.

3.2 Assumptions

The assumptions used for this ethnographic case study were determined to conceptualize implementation of early STEM lessons in an authentic manner. At this point, one of the assumptions of this study is that the students engaged and interacted with their group members and also with the teacher during early STEM lessons. In addition, it was also assumed that the information collected from the classroom observations and interviews with the students and the classroom teacher was enough to understand students' authentic learning experiences and interpretation of engagement of them in early STEM lessons.

3.3 Participants

Early STEM program that was developed for K-4 students has been applied in 10 private schools in six different cities of Turkey and among them; one school was selected to collect data for this present study, since this program was implemented few schools in Istanbul and the school that was selected for this study applied the program in the best way and the 4^{th} grade classroom teacher. Participants consisted of 13 4^{th} grade

students and one classroom teacher who teaches the 4th grade students that were the sample of the study and the teacher also has 5 year teaching experience. The classroom teacher was also selected for the reason that he involved in the preparation process of early STEM program boks [103] and also showed effective participation to early STEM program.

4 out of 13 participants were male and 9 of them female. Participants were 4th grade students as stated earlier and their age interval were in 8-9. Also, all of them attended all early STEM lessons throughout the year. On the other hand, students did not take STEM or any similar course before early STEM program. So, they have received such a course for the first time. Moreover, the professions of the parents of children are also varied such as electrical engineer (father of 1 student), marine engineer (father of 1 student), architect (father of 2 students), financial advisor (father of 1 student and mother of 1 student), pilot (father of 1 student), teacher (mother of 2 students), manager (father and mother of 1 students) etc. This information was also important for this present study since students have prior knowledge about different professions during early STEM lessons.

In addition, all students and the classroom teacher participated voluntarily and their consents were taken before conducting the study. The teacher was informed about the study process (Appendix- C) and also researcher met with students and also gave some information about researcher role during early STEM lessons before starting the observations. From this perspective, when considering the goals of the study, participants were selected in a purposeful way. That is, purposeful sampling method was used, because this method was suitable when the goal of the study is to understand something and also when the generalization is not needed [83].

3.4 Ethical Issues

For ethical considerations, firstly approval of the BAUSTEM Center was taken to conduct the study under early STEM Program. Then school administrator, teacher and students were informed about the intent, the implementation process and the confidentiality of student identities. At the end, permission was taken each of them to participate in the study. The process of obtaining permission is as follows:

1. The researcher approached BAUSTEM (early STEM program developer) to seek permission (appendix-A) for the study to observe the early STEM lesson in a 4th grade classroom and to make interview with students.

2. The researcher approached the school administrator to seek permission (appendix-B) for the study to observe the early STEM lesson in a 4th grade classroom and to make interview with students.

3. The researcher, with assistance from the BAUSTEM center, identified a potential classroom teacher for participation selection to observe early STEM lesson and sent a consent form (appendix-C) describing the nature of the study and expectations from him. A copy of the consent form was also provided to the teacher.

4. Once the teacher expressed interest, the researcher met the teacher face-to-face at a mutually agreed time and location. During that meeting the researcher explained the study fully, observation protocol (appendix-H) and then encouraged the teacher to ask questions about the process.

5. Once the teacher's permission was taken, the researcher approached the teacher's class of students for further solicitation of students to participate as indirect or direct, because in qualitative research every person plays a role in the research environment either directly or indirectly. Students who were considered as direct were both observed and interviewed, while indirect participants were just observed. The researcher delivered a brief presentation to the students to define direct/indirect participation and to explain the research purpose and questions about the procedure of the study. At the end, all students were direct paritcipants in this present study. Although, information about the interview protocol (appendix-D) was given, the detailed information was presented just before the interview process and also students' permission was taken orally to be audio-taped.

3.5 Instruments

This qualitative ethnographic case study conducted in early STEM lessons, where a group of students share a space of classroom and experienced integrated STEM activities. In addition, in order to increase the objectivity of this ethnographic case study, more than one data collection tools were used. That is; the authentic learning experiences and engagement of students into early STEM lessons was captured during

classroom observations and interviews with students and also interview was done with classroom teacher in order to investigate the process more deeply.

3.5.1 Classroom Observation Field Notes and Setting

The field work for this ethnographic case study took place in a classroom situated in the early STEM lessons in one of the campus of the private school in Istanbul and observations were made in a 4th grade classroom. The actions within the classroom present important data for experiences of students in a natural setting and also the implementation process of early STEM phases as students engaged in learning. The field work consists of 8 classroom observations totally was guided by an observation protocol which was designed based on authenticity model and STEM learning cycline. These two models also constituted the conceptual framework of the present study as stated in chapter 2.

The combination of Authenticity model and STEM Cycline was formed in the light of their similarities on characteristics and assignments based on weekly progress of the early STEM program.

Table 3.1 Combination model of STEM cycline and authenticity types

Types of Authenticity	***Key Definitions***	***Phases of STEM Learning Cycline***	***Assignments based on weeks***
Context Authenticity	*Context Authenticity* situates the work in reality and allows students to gain genuine understanding of a phenomenon in a scientific way. It helps "bring real world experience to the classroom" (Strobel et al., 2013, p. 147).	1st Week *Engagement / APKS*	Presenting the real-world problem statement (APKS) Questioning Creation of groups Taking responsibilities
Task Authenticity	*Task Authenticity* occurs when students are engaged in the type of work actually done within a profession. Authentic tasks "challenge students in decision-making in practical contexts" (Strobel, et al., p. 147).	2nd Week *Exploration / Fact finding*	Recalling the real-world problem (APKS) Revealing students' pre-knowledge about subject matter Searching information to solve the problem Ways of getting information; sources of information Using acquired knowledge
		3rd Week *Exploration / Ideation*	The ways of creation idea Expression of the ideas Selection of the best ideas Using acquired knowledge
Impact Authenticity	*Impact Authenticity* occurs when student's work impacts the real world in some way. The impact may take the form of "participation as effective citizens" and promote "minorities' experiences in the role of engineers and scientists" (Strobel et al., 2013, p. 147).	4th Week *Explanation / Product development*	Recalling the real-world problem (APKS) Sketching the ideas (drafting) Designing of the product Improvement of the developed product
		5th Week *Elaboration / Product development*	Development of the product Deepening the learning
		6th Week *Explanation-Elaboration / Refinement*	Development of the product Deeping the learning Testing the developed product
Personal/Value Authenticity	*Personal Authenticity* involves students' personal culture and professional goals. It allows the learning activity to do more than "simply [prove] their competence" (Strobel et al., 2013, p. 147).	7th Week *Evaluation / Dissemination*	Evaluation of the learning and product Preparation for the expo Preparation of the portfolios Trial presentation of the products to the class
		8th Week *Expo Week*	Group motivation Presentation of the products to visitors/ parents Reviewing the process

At this point, table 3.1 represents description of the phases and the connections between these two models (Authenticity Model & STEM Learning Cycline). That is, the phases of STEM Learning Cycline were related with the types of authenticity and the 8-week application process was examined by establishing the links between them. For example, first week of early STEM program APKS was explained to students and this process was associated with Context Authenticity, since this type of authenticity brings real-life situations into classroom as occurred in the first week of early STEM lessons (APKS was introduced to students). The APKS for the "My World of Imagination" Theme was "The Mars space station is expanding and the Mars population is increasing. You should build a new «Space Dome». Determine the design of this dome (in Turkish: Mars'taki uzay istasyonu genişliyor ve Mars nüfusu artıyor. Yeni bir «Uzay Kubbe» inşa etmelisiniz. Bu kubbenin desenini belirleyiniz)" Based on this problem, students connect their mathematical knowledge with real-life situaitions. That is, they were aware of the concept of tessellation comes from the patterns in mathematics. The table 3.1 also guided to take notes during the classroom observations. These combinations were directly related to the research questions, which are;

1) How do students perform authentic learning experiences in Early STEM lessons?

2) In what ways do students engage in Early STEM lessons?

3) In what ways authentic learning is integrated in Early STEM lessons?

To construct content validity, while constructing the combination of Authenticity Model and STEM Cycline, views of two more researchers who are experts on this subject were taken and also one of these researchers was the early STEM program officer. Then the relevant literature was examined and also by considering the framework of the present study, the researcher created this framework to collect and analyze the observation field works.

3.5.2 Semi-Structured Interview

In this ethnographic case study, interview protocol consisting of semi-structured questions was created to reach deep understanding on the research problems and to find answers for research questions as in classroom observations. The interview instruments were also created for both students and classroom teacher, that is, two interview instruments were generated.

Semi-Structured Interview with the Students

The student interview consisted of three parts included demographic information for students, questions for reminding themes or phases of early STEM program and interview quesitons about each phase of the early STEM implementation process that lasted eight weeks. The first version of the instrument consisted of two parts which were only demographic information and interview questions. After receiving expert opinions, reminding part for phases of early STEM program was added since interviews were held during the implementation of the program's final theme and so students may have forgotten what they did in the previous themes. In other words, this part enables students to recall what students produced in each theme and in what ways.

Beyond this, while constructing interview questions three expert opinions were taken. One of these experts was the early STEM program officer and she gave feedback about asking questions on the application of the program and the understanding of what the students achieved during this process. Another expert was the pre-school teacher who has 20 years teaching experience, so she also gave some recommendations on question patterns and level of understanding of questions, because this interview was done with 4^{th} grade students. The third expert was the advisor of the present study and he gave feedback on the compatibility with the research questions. In the light of these views, interview instrument created with 13 main questions in the third part following 5 questions in the first part (demographic information) and 4 questions in the second part (reminding questions). In *Appendix-D* the original interview protocol and questions were presented and the English version of this instrument was also given as in *Appendix-E.*

Semi-Structured Interview with the Teacher

The teacher interview was consisted of three parts: Questions regarding the implementation of early STEM lessons, questions on the early STEM program process and questions about the reflection of early STEM lessons on students. In *Appendix-F,* the original interview protocol and questions were presented and English version of this instrument was also given in *Appendix-G.* These questions were also created in the same manner as occurred in the preparation of student interview questions, which means expert opinions were taken while constructing the interview questions and it

included totally 18 questions. Also, the questions of the teacher interview instrument were constructed after classroom observations in order to examine the research

questions more deeply. Therefore, the prepared questions focused on the point that the researcher did not fully understand, especially during observation. Namely, teacher's thoughts, experiences and roles related to the implementation process of early STEM lessons were observed but in order to understand these issues deeply teacher's views were also taken. In the same way, second part of the instrument focused on the students' engagement of the early STEM lessons during each phases in previous lessons. Third part was also prepared to learn the teacher's point of view about the reflections of early STEM lessons on students about the points that the researcher could not catch.

3.6 Data Collection Process

Table 3.2 Data Collection inventory for the study

Type of Data	Time
Classroom/ Observation Field Notes	45 minutes/ each visit (totally 8 classroom observation)
Students/ Interview	15-20 minutes/each student (totally 13 students)
Teacher/ Interview	20 minutes

During the data collection process of this qualitative ethnographic case study, ethnography and case study research designs were used as stated earlier. The methods used to collect and analyze the data from field notes and transcripts from field work included eight classroom observations, interviews with students and classroom teacher as shown on Table 3.2 which represents data collection process and provides a framework of type of data that was collected and average length of them.

Classroom Observation Field Notes

The data from the classroom observations were collected in a natural setting and during this process researcher had a role as a nonparticipant observer [82], that is, researcher did not have any effect on students' actions and implementation process of early STEM lessons. In order to capture and understand the authentic experiences of students,

students' engagement and student-teacher interactions, researcher just observed these actions and process in the natural setting through scientific procedure that includes protocols for data collection, coding process etc. [82].

According to Cresswell [82], field notes are a valuable and effective way to record experiences, culture, behaviors and interests of participants within their natural environment in the context of observer point of view. Therefore, in this ethnographic case study, field notes were taken in this context and events, discussions, experiences of students in the classroom as a natural environment based on research questions. Observation field notes are also effective and useful technique for data collection since by observing a situation, the nonverbal things beyond the verbal things can be also recognized [83]. So, in the present study, this issue was focused on by the researcher and authentic experiences of students in early STEM lessons was tried to be investigated.

Before observations were done, students and teacher were informed about the process of observation, which type of data collected from them and researcher roles during this time. In other words, from the beginning of the study to the end, the participants were aware that they were involved in the research. At this point, in the present study, totally 8 classroom observations of the last theme of the early STEM program *(My World of Imagination)* were done and each lasting 45 minutes (one lesson hour) per week. That is, there was only one lesson hour of early STEM lessons per week and these lessons were observed for 8 weeks by the researcher. Observation notes were written during this process based on the authenticity model and STEM cycline and in these notes, some elements were reported about authentic experiences and engagement of students in early STEM lessons. Following each visit of the early STEM lessons, researcher became familiar with the setting as well as interactions between students. So, after each visit data were collected in a more detail way and in-depth.

Semi-Structured Interviews

The interview is conducted within the scope of interactions between researcher and participants in a structured or unstructured way in the light of research questions [82] and this process is guided by perceptions, views, relationships and assumptions of participants [82], [83]. In this ethnographic case study face-to-face semi-structured interviews were done with 4th grade students and also classroom teacher in the light of

research questions (see Appendices D & F). Also beyond the research questions, interview questions were partially structured by the information collected from classroom observations that were done prior to the interviews.

The interview protocols for this ethnographic case study were included two semi-structured interviews: both of them were face-to-face and included open ended questions, but one of them conducted between researcher and students while the other with teacher.

The interviews for this qualitative ethnographic case study were scheduled and completed following the classroom observations. In other words, after each observation of early STEM lesson, interviews were done with 2 or 3 students in a comfortable place, usually performed in an empty classroom in the school and in the teacher room; interview was also done with classroom teacher after the last theme was implemented. Furthermore, the interviews were audio-taped and then their transcriptions were made by the researcher. The length of the interviews has changed depending on external and internal circumstances, but average lasted 15-20 minutes with students and 25 minutes with the classroom teacher. During these face-to-face semi-structured interviews, hand written notes were also taken to present the behaviors of students and also classroom teacher since some actions as emotional responses to the questions cannot be understood from the audio-recorder.

3.7 Data Analysis Process

Qualitative researchers focus on theoretical and conceptual frameworks while analyzing collected data in order to ensure academic rigor and trustworthiness. The research problem, questions and purpose also guide the analysis process of the data.

In the light of the frameworks for this ethnographic case study, the research data collected from observation notes and interview transcripts were analyzed through inductive analysis. This type of analysis is chosen to reveal meaning from collected data and allows researchers to generate broader themes by examining and comparing similarities and differences in collected data [82]. In other words, researchers collect data from various methods and then these data are organized and grouped by exploring relations and clues within data; so in inductive process as a theoretical perspective, it is aimed to reach a sense of meaning from the various forms of data collected from different methods.

In the light of inductive data analysis process firstly, codes were determined by two researchers from field notes and transcripts based on authenticity model and STEM learning Cycline as conceptual framework. While coding the notes from collected data, initial and process coding were used: initial coding for interview transcripts and process coding for observation field notes [91]. Process coding ensures that observer focus on the actions and situations of participants during observations while initial coding provides a guidance evaluating data collected from interviews and also reorganizing them [91].

Beyond this, there are 10 authentic elements that represent the 'essence' of authentic learning [81]. By considering also these elements, data were transferred using codes by grouping the information based on the models and authentic elements and then some categories and themes were generated. In this manner, the process of transformation of data for analysis for this qualitative ethnographic case study included managing the data, reviewing the texts from field notes and transcripts, organizing the information, coding, identifying categories and themes from codes, and presenting the information incorporating the experiences of the students and teacher.

3.8 Trustworthiness

In order to ensure the trustworthiness of the analysis of data, triangulation strategy was used in this ethnographic case study. Triangulation means that combination of the two or more theories, investigators, data sources or methods in one study about a single phenomenon [90]. Also, Savin and Baden [83] explains triangulation as "...the researcher has multiple data points that can broaden their understanding of the subject of their research (p.478) [83]" In this study, the advisor as another researcher identified possible codes in the three interview transcripts and also three classroom observation notes independently from the researcher and these codes were compared with each other. When there is consistency among the codes which were formed by the researcher and additional reviewers, the corroboration was proven. Beyond this, when there are differences, the overall codes were discussed again until a consensus was reached on the final rating. On the other hand, the views of the early STEM program developer as another expert were also taken for the determined codes to satisfy triangulation. Furthermore, while providing triangulation as stated above, credibility and also conformability which are other factors that provide trustworthiness [83] were ensured in the way of using the constant comparative method by comparing the data in a single case.

CHAPTER 4

RESULTS AND DISCUSSION

The aim of the study was to investigate students' authentic learning experiences through early STEM lessons. In the light of this aim, the following research questions also guided the study:

1) How do students perform authentic learning experiences in Early STEM lessons?
2) In what ways do students engage in Early STEM lessons?
3) In what ways authentic learning is integrated in Early STEM lessons?

In this chapter, the research results of the present study were presented within three parts as process of coding, creating categories and forming themes by considering the aim and research questions. The discussions of the research results were also supplied by comparing and interpreting them through related literature.

The field work and interview transcripts analysis was approached in an inductive way [82] (explained in data analysis process part in chapter 3) to identify the codes firstly and then 14 categories and three general themes derived from the data. And these results represent the early STEM classroom implementations in an authentic manner.

4.1 Ethnographic Case Study Codes

The early STEM lessons were observed during 8 weeks and each week some assignments were implemented by considering the phases of early STEM program. The observed theme was the "My World of Imagination", but students' and classroom teacher's views were also taken for all themes and whole program during interviews. According to Authenticity Model [86] and STEM Learning Cycline [4] and also by considering the 10 authentic learning elements [81], codes were determined from collected data and the codes were grouped for each early STEM phase (see table4.1).

Table4.1 The codes derived from the data based on STEM Learning Cycline and Authenticity Model as conceptual frameworks

Phases of STEM Learning Cycline	*Types of Authenticity*	*Authentic Learning Elements*	*Codes*
APKS	Context Authenticity	*1. Real world relevance*	- Open-ended exploration - Defining real world problem - Higher order reasoning - Taking responsibility - Relevance with real life - Problem solving *(Challenging real-world problems)*
Fact finding Ideation Product development Refinement	Task Authenticity Impact Authenticity	*2. Ill-defined problems* *3. Sustained investigations* *4. Multiple sources and perspectives* *5. Collaboration* *6. Metacognition (reflection)* *7. Interdisciplinary perspectives* *8. Integrated assessments* *9. Polished products* *10. Multiple interpretations and outcomes*	- Planning and conducting investigations - Deep approach to learning - Transferring (prior)knowledge into real-life - Critical thinking - Integrating multiple disciplines - Observation skill - Interacting with STEM occupations - Developing and using model - Modeling authentic problems - Learning environment (classroom, materials...) - Problem solving skills - Learning by trial-error and personal explorations - Designing multiple solutions - Designing hands-on STEM applications - Comfortability with using tools - Developing motor skills - Relating multiple disciplines/ Interdisciplinarity - Productive teamwork - Students interest and motivation
Dissemination/ Reflection	Personal/Value Authenticity		- Students' curiosity, self-management, self critism, creativity, interest and motivation by self-efficacy beliefs on STEM - Evaluating and communicating knowledge with society - Building social skills

At this point, this part represents the important points and elements occurred during each week of early STEM program. That is, the determined codes were presented by phases of STEM Learning Cycline and authenticity types and also some phases were combined due to similarities of data results collected from those phases.

APKS-Context Authenticity Codes

In the first week of this program, the APKS (Authentic Problem of Knowledge Society) was introduced to the students, also working groups were created and responsibilities were given to each group member through their professions selected for that theme. Namely, for the last theme of early STEM program which was called as "My World of Imagination"; architect, design and development engineer and industrial designer were

the professions that the students undertook until the end of the theme. Beyond this, some responsibilities were also given to students such as presenter, plotter, portfolio designer, quality controller and in this way, they also gained the consciousness of taking responsibility that was also one of the codes. In this manner, this week was related with context authenticity type which associates the works with reality and also "bring(s) real world experience to the classroom (p.147) [86]". In the relatedness of these frameworks, 6 codes were emerged for the first week of early STEM lessons as seen also in table 4.1.

In the beginning of the early STEM lesson, students' interests were taken with some visual materials on the topic and so their engagement was supplied. Then, a real-life problem with some constraints was given to solve them and students tried to understand the problem. While interpreting the problem, they made some explorations and asked questions to classroom teacher related with the real-life problem statement. For example, during the observation of the first week of early STEM lesson, it was pointed that there is a unique situation in the APKS disclosure process and students were aware that they should be able to offer scientific solutions to this problem and should make the solution concrete. That is why; they listened carefully to the teacher's explanations and took notes. Also one of the students expressed that *S1: "…[APKS] was more about thinking… (in Turkish: …daha çok düşünmeye yönelik oldu)"*, so students could improve their higher order thinking skills through APKS. During the observation, it was also seen that the APKS was repeated several times in terms of the adoption of the students and the statements in the APKS were explained with respect to the daily life in terms of being more meaningful. Furthermore, since APKS cannot be easily solved and is open to more than one solution pathway, it has been determined during the observation that the students' mind somewhat confused at this point. Since they can not define the problem precisely and clearly, they have begun to think about the concepts in APKS. The teacher also gave an open-ended research area to the students by explaining what the concepts like dome or pattern within APKS would look for in this process. At this point, students may be unfamiliar with some concepts since they are young, so each concept should be carefully studied and focused on a thorough understanding of the topic [20], [49], [50]. In this way, students can make a meaningful product correctly and can learn the subject authentically since the means of authenticity is real and true [80], [81]. In other words, in this lesson, students were engaged with problems and authentic

learning has been carried out through this problem which required them to use their prior knowledge, associating it with real life.

In this manner, to make the problem even more meaningful, examples from daily life were asked to the students. In this way, the transfer of the acquired knowledge has been carried out by focusing on the relevance with the real life. Students were challenged with the real-world problems by using their higher order reasoning skills. In this manner, some students' views on early STEM lessons and APKS as following:

S6: Early STEM has made it possible for us to learn what we will learn in the future.

It was a nice thing, so we were learning new things. For example, we learned why beavers made a dam (in Turkish: erken STEM ilerde öğreneceğimiz şeyleri şimdi öğrenmemizi sağladı. Güzel bir şey yani yeni şeyler öğreniyorduk. Mesela kunduzların neden baraj yaptığını öğrendik).

S9: It has developed my imagination (in Turkish: hayal gücümü geliştirdi).

S13: In early STEM lessons, we are strengthening our brains. Well then we have a growing power to develop products (in Turkish: Erken STEM derslerinde, beynimizi güçlendiriyoruz. Şey sonra ürünleri geliştirme gücümüz artıyor).

These quotations provide an insight on how introduction of an APKS affected students' interpreting and thinking skills. Beyond this, the APKS had also some constraints and in one of them, there was the mathematical concept of "Tesselation". While one of the students was reading this concept, she hesitated for a moment and she probably did not know its meaning. With early STEM lessons, students have also learned different concepts that they may use in their future professional lives.

Another point that attracted attention this week's lesson was the sense of taking responsibility. Namely, in one of the groups, responsibilities still could not be shared because especially the student "S10" was not satisfied with his responsibility and he asked to change it in every moment of the lesson. Although students are dominant during the process, it is difficult to persuade them because of the age groups and one example of this was observed in this lesson. In this situation, classroom teacher's directions became effective to solve the problem by saying that students can share the responsibilities within the group and students were agreed to take responsibilities in turn, and the problem was resolved. At this point, STEM lessons based on group interactions and collaboration have an important place that means, it is important that students undertake their responsibilities and collaborate in projects. Thus, they can recognize the importance of their choices and behaviors in the process and this leads

them for their daily and professional life. Also, Mims [17] explained that "Authentic learning is a pedagogical approach that allows students to explore, discuss, and meaningfully construct concepts and relationships in contexts that involve real-world problems and projects that are relevant to the learner (p.2) [17]" Through the first week of early STEM lesson, students constructed these experiences by stating the APKS and so context authenticity has been emphasized. Garrett, Huang and Charleton [92] gave an example for context authenticity as "[For example] students may be asked to design a product within constraints such a design would actually require, such as a container for a product that minimizes the amount of material needed (p.36) [92]". A problem (APKS) that is in the same direction with this example was also addressed in early STEM lessons. That is why; we can see the relations between the context authenticity and APKS week of early STEM program.

From these perspectives, 6 codes were emerged from the collected data for the first week through classroom observations and interviews as following: *Open-ended explorations; Defining real world problem; Higher order reasoning; Taking responsibility; Relevance with real life; Problem solving (Challenging real-world problems)* (see Table 4.1).

Fact Finding & Ideation-Task Authenticity; Product Development & Refinement-Impact Authenticity Codes

In the second week of this program, students made some researches to solve the APKS and during this time they asked to the teacher, their group members and also looked at the books or internet about questions they should answer to reach the best solutions. For instance, when the teacher wanted to give the students an example in order to fully understand what the dome is like, one of the students gave an example of fairy chimps by examining the shapes on the posters in the classroom. This also shows that students have developed their observation skills and how to search and what resources they can benefit from. They saw everything in their environment as a source of information, so they seemed to have gotten the necessary gains about the research process. Another student also said that we had a dome in our head. This is an indication of in what way the students have observed and imagined is wider. Besides examining the assets in the environment, it is an important point to give examples by observing and examining itself. This shows the vision and perspective that early STEM lessons added to the students. At this point, students reached the deep approach to learning by transferring

their prior-knowledge into real-life. In addition, while searching on information they should have, students used multiple sources. For example;

S5: "from documents ... or computers... (in Turkish: ... belgesellerden… ya da bilgisayardan…)"

S9: "Internet, then videos we watched on the topic… (in Turkish: İnternet, sonra izlediğimiz konularda videolar izlemiştik onlar)"

S7: "We got help from the computer, we worked. We asked all my parents. Then we gathered all the information and offered all of them to each other (in Turkish: Bilgisayardan yardım aldık, çalıştık. Annemize babamıza sorduk işte hepimiz. Sonra bütün bilgileri toplayıp karşılaştırdık böyle hepsini birbirimize sunduk)"

From above quotations, the use of internet seems to be the most frequently used source of knowledge to reach and make sense of information. But, we can also understand that students used multiple sources despite the fact that internet is the mostly used resource; they also asked each other and also their parents. This was the indication of how learners learn both individually and in group.

On the other hand, in this process students also filled out the information books that they write their investigation results for reseacrh questions about APKS. One of the students found an information for the concept of tessellation, but the acquired information contained too many foreign words. Therefore, some students still do not know which sources and information are useful and which are not. Conducting research; the process of acquiring knowledge forms the basis of early STEM lessons. Only one week has been given to this process and it has to be done correctly, because they get basic information at this point and the knowledge they acquired shapes the other process of the program. Namely, planning and conducting investigations are at the forefront in this process. Beyond this, some codes were also determined through fact finding phase such as deep approach to learning, transferring the prior knowledge into real-life, critical thinking.

In the third week of the program, the students developed ideas about the product they would design and during this process; they asked what they are going to do by talking among themselves and in time, ideas were exchanged within the groups. The students in the group put forth their ideas and they were thinking about choosing the best. They also get the teacher's idea for their solutions. These implementations ensured the

productive teamwork and problem solving skills since students decided which of the different ideas would be better and suitable by taking into account each other's views. These situations were related with the type of task authenticity which "challenges students in decision-making in practical contexts (p.147) [86]" That is, students decided which idea was the best solution to solve APKS and work well. Acoording to Renzulli et al. [93], the problem should be open to explore and students should have a choice to define the problem and to select the frame for its solution. This situation also proves that authentic learning activities are student-centered as stated in the studies of Maina [94] and Callison and Lamb [95]. To summarize, students designed multiple solutions for an authentic problem within productive teamworks and they shared their learnings with group members and the classroom teacher. In this manner, some of the students stated during interview that S3: "[we] are developing our imagination, teamwork and enjoying our knowledge (in Turkish: hem hayal gücümüzü geliştiriyor, takım çalışmasını geliştiriyor ve eğlenceli geçiyor)" S2: "What has been added to me .. Group work, like skill. (in Turkish: Bana neler kattı.. Grup çalışması, böyle beceri gibi.)" That is, in the early STEM lessons, collaboration which is one of the authentic learning elements was ensured and students were also aware of it.

After designing what they will do to solve APKS, within the next three weeks students worked on to produce their products. Giving importance to students' preferences, polling for preliminary information, discussing new information together and sharing ideas were identified as effective teaching strategies in this process. Students showed great success while developing their products and solving the problem. They have started to make designs that they have already created in a way that they will create patterns with the colors they want. It can be also argued that children were continuously increasing their confidence in the work they do, as the teacher was constantly guiding the students. Also, the effect of using positive language, giving children the opportunity to do what they want and reinforcement method were observed during this process. The students voluntarily and actively participate in the process and implemented their own ideas, which was also the indicator of the high motivation. In this manner, during the interviews, some students were asked about the most enjoyable part was product development. For example:

S9: When painting Amsterdam houses, while sticking the pattern things out (in Turkish: Amsterdam evlerini boyarken, örüntü şeylerini kalıpla çıkarırken üzerine yapıştırırken…)

S13: When I was doing the Amsterdam house, my things got dirty. I like it I did a lot of work like that (in Turkish: Amsterdam evini yaparken, ellerim falan kirlendi. Hoşlanıyorum böyle çok fazla iş yaptım)

S5: Dying in Amsterdam houses. Then, I liked the railing at the dam too (in Turkish: Amsterdam evlerini boyamak. Sonra, barajda da korkuluk yapmak çok hoşuma gitti)

S2: … that's [product] what we achieve. Show us our skills (in Turkish: … başardığımız işi gösterir bu. Becerimizi gösteriyordu)

Some psychologists like Piaget believe that students should be active during an activity to ensure the real learning [96]. Also, authentic learning is about learning by doing that students being active [73]. In the product development phase, students mostly took active role as in other phases and their motivation was high as mentioned during the interviews. Beyond this, the active involvement and encouragement of students in the process is an outline of early STEM lessons and in these lessons the example of this was observed quite clearly, especially in product development process. From this perspective, this process was related with the type of impact authenticity which is about usability of the created designs in the real-life environment for example, during early STEM program, students built a dam, machines with pulley system or built a dome by using tessellation art. So, all of these products can be used in real life situations since they were produced to solve a real-life problem and in this time, they have developed their products within the framework of responsibilities like a profession and a real business life.

In these perspectives, 19 codes were emerged for four phases of early STEM program (see Table 4.1). In general, it can be resulted that STEM activities contribute to the cognitive and physical development of students, especially at early grades, by providing an authentic learning environment, unlike other activities. Also, most of the students engaged in early STEM activities became successful in designing and modeling solutions for a real-life problem through productive teamwork and authentic learning experiences.

Dissemination/Reflection-Personal/Value Authenticity Codes

In the last week of the program, students presented their products to their friends, other teachers and also their parents through an expo week. During this time, they exhibited what they did, how they designed their products and for what reason they conducted this project. In other words, in early STEM program, the combination of cognitive process and social product emphasized in the STEM cycline was important and each of the eight-week themes concluded with an exhibition and sharing day that informs the families and teachers of the young age group what they were doing in that cycle [87]. This process is an indicator that social product objectives were foregrounded, that is, while students presenting their products, they have also improved their social skills. This has also important place in authentic learning experiences which include personal/value authenticity type. According to Strobel [86], personal authenticity takes place when the subject matter affected the students' lives or related with them. It also has an influence in the professional choices of the students. Value authenticity ensured the students' self-learning skills and some examples for this were seen during interviews and classroom observations.

S5: I was a bit embarrassed [during presentation], but I was happy to tell. I was happy to inform people (in Turkish: Biraz utanıyordum ama anlatınca mutlu oluyordum. İnsanlara bilgi vermekten mutluluk duyuyordum)

S4: Mostly I am preparing questions, for example, I am telling a person, then I am pulled out to the side, my friend is on duty (in Turkish: Çoğunlukla soruları hazırlıyorum ben, mesela bir kişiye ben anlatıyorum, sonra ben kenara çekiliyorum, arkadaşım görev alıyor) – example of collaboration and taking responsibility.

S5: During the presentation, we usually try to tell something pleasantly, not too long, and we tried to tell it in a fun way (in Turkish: Sunum sırasında genellikle yanlış bir şey yapmamaya, çok uzun anlatmayarak, başkalarının canını sıkmadan, zevkli bir şekilde anlatmaya çalıştık) - Communicating knowledge with society.

From these perspectives, learning is supplied through a social interaction [73] and early STEM lessons provided this with authentic learning experiences. In other words, beyond cognitive developmental skills, students could also build and improve their social skills through this program. In this manner, three codes were emerged from interviews and classroom observations (see Table 4.1).

4.2 Ethnographic Case Study Categories and Themes

Based on the collected data from classroom observations and interviews, three themes were determined in the light of 14 emerged categories from codes and they also provided some insights on how authentic learning elements or characterictics took place in early STEM lessons.

The themes emerged from the qualitative data analysis for this ethnographic case study of early STEM lessons are: 1) Authenticity vital role in early STEM education, 2) Early STEM effectiveness in authentic environment, 3) Essential role of early STEM education upon students' authentic learning experiences (see table 4.2).

The actions in the classroom and the views and comments of the students and also teacher during interview were used to interpret themes that explained students' authentic learning experiences in early STEM lessons.

The first theme addressed the role of authenticy in early STEM education, then second theme provides knowledge on early STEM effectiveness in an authentic environment for example; STEM careers, STEM learning, STEM applications etc. Finally the third theme was used to represent role of STEM education in authentic leaning experiences.

Table4.2 Analysis of data based on STEM Learning Cycline and Authenticity Model as conceptual frameworks

Phases of STEM Learning Cycline	*Types of Authenticity*	*Authentic Learning Elements*	*Codes*	*Categories*	*Themes*
APKS	Context Authenticity	*1. Real world relevance*	- Open-ended exploration - Defining real world problem - Higher order reasoning - Taking responsibility - Relevance with real life - Problem solving *(Challenging real-world problems)*	- Pointing out real-world problems - Developing STEM awareness	
Fact finding Ideation	Task Authenticity	*2. Ill-defined problems* *3. Sustained investigations* *4. Multiple sources and perspectives* *5. Collaboration*	- Planning and conducting investigations - Deep approach to learning - Transferring (prior)knowledge into real-life - Critical thinking - Integrating multiple disciplines - Observation skill - Interacting with STEM occupations - Developing and using model - Modeling authentic problems - Learning environment (classroom, materials...)	- Students' thinking, observation, problem solving skills, metacognition, higher order reasoning and open-ended inquiry are addressed - Enabling making choices to reflect students' own learning into real life situations/problems - Gaining insights into STEM careers - Experience real world STEM applications	** Authenticity vital role in Early STEM education* ** Early STEM effectiveness in authentic environment* ** Essential role of Early STEM education upon students' authentic learning experiences*
Product development Refinement	Impact Authenticity	*6. Metacognition (reflection)* *7. Interdisciplinary perspectives* *8. Integrated assessments* *9. Polished products* *10. Multiple interpretations and outcomes*	- Problem solving skills - Learning by trial-error and personal explorations - Designing multiple solutions - Designing hands-on STEM applications - Comfortability with using tools - Developing motor skills - Relating multiple disciplines/ Interdisciplinarity - Productive teamwork - Students interest and motivation	- Building STEM knowledge and skills - Building interdisciplinary perspective - Spatial importance for STEM learning - Building knowledge on scientific and engineering practices - Gain hands-on STEM learning experiences - Developing physical attributes	
Dissemination/ Reflection	Personal/Value Authenticity		- Students' curiosity, self-management, self critism, creativity, interest and motivation by self-efficacy beliefs on STEM - Evaluating and communicating knowledge with society - Building social skills	- Engaging students in social learning in a community - Developing personal attributes	

4.2.1 Authenticity Vital Role in Early STEM Education

The authenticity was used in education to ensure the practical knowledge in a real world situation [81], [97]. In education, authentic problems or tasks aim to engage students in authentic activities that they make connection with their personal or professional lives [98]. In other words, transfer of knowledge into real-life situations are supplied. Burton [75] also described the authenticity as implementation of real-world problems in and outside of the classroom.

The categories of this theme are pointing out real-world problems; students' thinking, observation, problem solving skills, metacognition, higher order reasoning and open-ended inquiry are addressed; engaging students in social learning in a community; enabling making choices to reflect students' own learning into real life situations/problems.

The category, ***pointing out real-world problem,*** is about that students should be able to propose solutions to the real-world problems they face. In this manner, early STEM lessons involve authentic tasks that address real-world problems and engage students to define problems in their own lives as well as investigating and creating solutions for them. During interviews students were asked to give an example for real-world problem that they encounter and their ideas were taken ideas about how to solve that problem. So, environmental problems were the most mentioned ones by students and some quotations from students on how to solve it are as follows:

S2: ...first [I get information]. After that, I thought of what I could do. After that, start practicing and then I evaluated the result (in Turkish: Evet önce [bilgi edinirdim]. Ondan sonra ne yapabileceğimi düşünürdüm. Ondan sonra uygulamaya başlardım ve sonar sonucu değerlendirirdim)

S6: There are no trees. I want to plant small tiny grass [to solve this problem]. I want you to be everywhere in the woods and tell people this (in Turkish: Hiç ağaç yok. [Bu problemi çözmek için] küçük küçük çimenler dikmelerini isterim. Her yer ormanlık olsun isterim ve insanlara bunu söylerim)

S10: No skyscrapers, instead of it, there should be small houses. I tell the people the damages of the skyscrapers, the weather is destroyed. I say that this problem can be solved by making small houses. I can do other research myself, like how other solutions might be (in Turkish: İnsanlara gökdelenlerin zararlarını ve havayı bozduğunu anlatırım. Küçük evler yapılarak bu sorunun çözülebileceğini söylerim. Kendim başka araştırmalar da yapabilirim, başka nasıl çözümler olabileceği gibi)

As understood from students' answers, they have the ability to identify the real life problem and present solutions for a problem. Beyond this, water problems or needs, animals' protection, traffic etc. These examples also show that students improved the problem solving skills in recognizing and eliminating them by offering different solutions. In the same manner, students also exhibited great attention to solve given problem by developing various solution proposals. Therefore, early STEM lessons provided an insight on authenticity since it is related with real-life problems or situations.

The category, ***students' thinking, observation, problem solving skills, metacognition, higher order reasoning and open-ended inquiry are addressed,*** is about the abilities that the students have gained during early STEM lessons as well as in authenticiy. During the interviews and observations, it was observed that the students developed skills from many perspectives.

S2: ... Because if it gets even more polluted, it will become an ozone layer or something, it will be ruined. Our world will become uninhabitable (in Turkish: ...çünkü eğer daha da fazla kirlenirse ozon tabakası falan şey olcak, mahvolacak. Dünya'mız yaşanmaz hale gelcek.) - (critical thinking)

S3: The bridge between Earth and Mars. I thought the cause was a bit logical too. According to my knowledge of Mars in the solar system, the fifth place is that the Earth ranks fourth. Because they are close, I thought you could build a bridge (in Turkish: Dünya ve Mars arasında köprü kurulması. Nedeni de birazcık mantıksal da düşündüm. Güneş sisteminde Mars'ın bildiğime göre beşinci sırada, Dünya'nın dördüncü sırada olması. Yakın oldukları için köprü kurulabileceğini düşündüm) - (critical thinking & higher order reasoning)

S9:It has developed my imagnation (in Turkish: Hayal gücümü geliştirdi) - (higher order reasoning)

S6: For example, I became conscious. I learned how animals live, how people imagine or what people know what they do (in Turkish: Bilinçlendim mesela. Hayvanların nasıl yaşadığını, insanları nasıl hayal gücü ya da ne biliyim insanların neler yaptığını falan öğrendim) - (open-ended inquiry & metacognition)

These examples showed the need for authentic learning skills that enable students to think creatively and critically. In addition, metacognition which is thinking on individual's own thinking ensures the effective self-assessment or self-learning [99]. In this way, students can direct and evaluate their own learning in early STEM lessons

since they are active during the whole process and they determine which knowledge should be necessary and how it can be applied in their products. Research indicates that further learning is taking place within students who were experienced metacognitive instruction with cooperative learning rather than ones who do not [100]. According to Rule [80], "Science is advanced through experimental and theoretical inquiry in which investigators engage in asking questions, conducting studies, drawing conclusions, revising theories, and communicating results to others; therefore, science teaching and learning should reflect the scientific process of knowledge construction (p.3) [80]"

In early STEM lessons, we saw an example of the Rule's statement, that is, students both asked questions and also found answers for asking questions and they constructed the knowledge in a meaningful way. Therefore, when it is handled with a wide angle, it can be said that it has developed the skills of the students from various directions and this is the role of authenticiy since authentic learning should involve true inquiry [95].

The category, ***engaging students in social learning in a community*** provides insights on how students engaged in cooperative learning and what are their roles during early STEM lessons. The learning community in authentic learning was described in two parts: "One part is the group of learners who work together to unravel the problem. Another aspect is the community setting in which the project is based (p.4) [80]" In early STEM lessons, students had the role of professional community which investigates the related disciplines of research area [80]. In other words, they tried to solve a real-life related problem within a group by taking some responsibilities in a professonal role. During this time, they were interacting with each other and they shared their works by deciding themselves. The student S3 stated in the interview that *"... I always help the team, I have always been president. It's a good thing to entertain them, and I always talked about not fighting anyone before I started the project. That was also important. I was trying to make it fun (in Turkish: ...Ben takımıma her zaman yardım ediyorum, şu ana kadar hep başkan olmuştum. Onları eğlendirmek için hem güzel bir şey, ve her zaman projeye başlamadan önce kimsenin kavga etmemesinden bahsetmiştim. Bu da önemliydi. Eğlenceli hale getirmeye çalışıyordum)"* This is an indication of how the student will take responsibility within a community. At the same time, she has achieved a coherent working ability within the group, and this student will be able to find a solution to the problems she will face in real life. Moreover, explaining why and how students make their products to their friends and family is an important influence on the development of social skills. In this manner, classroom teacher stated during the

interview that *"I saw they were very excited. So there were even people who gave sugar to the parents, so they were doing the actual grouping there. 'You tell me, as I'll do it' [students' sayings], there's a little bit more progress in the last phase you see how efficient it is, how much it works"* Namely, early STEM lessons have a role on students' social skills which is needed in real-life situations and students experienced how learning was situated within social community.

At this point, Vygotsky [101] emphasized the need for a sociocultural perspective to understand the world. In early STEM lessons, interaction and discussion of ideas within group members also ensured a baseline for the development of scientific understanding through a guideline to students such as posing related questions, reminding the APKS, resolving the problems within groups etc. Also according to Lee and Songer [102], students should experience scientific investigations to be aware of what scientists do during their research such as data collecting, sharing or communicaitng. Early STEM lessons provides this experience to students and these experiences form the important components of authentic learning experiences.

The last category of this theme, ***enabling making choices to reflect students' own learning into real life situations/problems*** is about how learning which was ensured during early STEM lessons is transferred into real-life conditions. For example;

S2: I learned where water sources can be used (in Turkish: Su kaynaklarının nerede kullanılabileceğini öğrendim)

S4: In my daily life, my father, for example, did not know Scracth since it's a children's program, so I taught him (in Turkish: Günlük hayatımda babam, örneğin bir çocuk programı olduğu için Scracth'ı bilmiyordu, ben de ona öğrettim)

1st week field notes: "In terms of being more meaningful of the APKS, it is explained by students and also teacher with examples and analogies in daily life (in Turkish: BTHP daha anlamlı olması için, öğrenciler ve öğretmen tarafından günlük hayattan örnek ve benzetmelerle açıklanmıştır)"

From these quotations, it can be seen that students would use their learnings in their daily life situations and also to deal with the encountered problems. Mims [17] also stated that "This ability to transfer their new knowledge and skill beyond the walls of the classroom and make practical application of it is the most powerful characteristic of authentic learning (p.7) [17]". Callison and Lamb [95] also specified that accessing information outside of the school ensures students to connect with real life and also enables them to interrogate the problems they face with the problems. It is necessary for students to use

their designs in their everyday lives and to find them meaningful so that the student can be transferred their learning to their real life situations. That is why; early STEM lessons provides these experiences in an authentic manner.

4.2.2 Early STEM Effectiveness in Authentic Environment

This theme represents the effectiveness of early STEM lessons in an authentic environment based on students' and teacher's views and also observation field notes by considering how students learn best and which factors were affected in this authentic environment during early STEM lessons. At this point, the categories that represent this theme are; gaining insights into STEM careers, building interdisciplinary perspective, experience real world STEM applications, building STEM knowledge and skills, developing STEM awareness, spatial importance for STEM learning.

The category**, *gaining insights into STEM careers*** is about the students' views and choices on their future careers. That is, during the early STEM lessons, students took a role of some professions which were based on STEM occupations in each theme of the program and they learned some theoretical and practical knowledge on these occupations area. This implementation had a significant role on students' future career choice since the best time to build awareness and interest in STEM fields is early school years [53], [54]. For example;

S3: I liked being a computer engineer. So I can do whatever I want to do. Designing is already going well, drawing is also nice. I love it so much (in Turkish: Bilgisayar mühendisi olmayı çok sevdim. Yani ne yapmak istersem yapabiliyorum. Tasarımım zaten iyi gidiyor, çizimim de güzel. Onu çok seviyorum)

Teacher: Of course, before we start the project, we have groups of professions that we divide into groups.When everybody gets their jobs, they get a little more confident here. They're investigating it a little more or when their friends explore it, they have a little more envy. So they know the profession exactly (in Turkish: Tabi ki yani projeye başlamadan önce gruplara ayırdığımızda, meslek grupları oluyor. Herkes kendi istediği mesleği aldığında, burada o mesleğe biraz daha yatkınlık oluyor. Biraz daha araştırıyorlar onu, ya da arkadaşı araştırdığında ona biraz daha imrenme oluyor. Yani meslekleri tam anlamıyla tanıyabiliyorlar)

S13: I liked being a pure scientist (in Turkish: Temel bilimci olmak hoşuma gitti)

S8: I want to be both electronics and an industrial engineer. I loved all of them because my drawing is fine. My father is already an architect, and I want to be an architect. The electronics are good for me (in Turkish: Ben hem elektronik hem endüstriyel mühendisi olmak istiyorum. Hepsini sevdim, çünkü çizimim iyi. Zaten babam mimar, ben de mimar olmak istiyorum. Elektronik de bana iyi geldi)

From above quotations, we can see that students were aware of most of the STEM professions and although both their background and interest have an effect on their career choices, their parents' occupations had also an effect on this choice. Constructivists also stated that the introduction of real life concepts into the classroom environment encourages learning [17] and in order to achieve this, learning environments should be authentic.

In this manner, Erdoğan and Stuessy [71] conducted a study to determine a framework for effective learning environment for specialized STEM schools and they determined three factors: actors (teacher, students, role models etc.), contextual factors (learning environment, curriculum etc.) and actions (teaching, learning, communicating, mentoring etc.). So, we can see all of these factors in early STEM lessons and it can be said that effective learning has been maintained in an authentic context.

Some skills such as creative thinking, problem solving, leadership, and innovation need to be developed to make learning environments designed to improve STEM education more useful [70]. At this point, Mims [17] also gave an example that:

"If students were engaged in an authentic lesson related to solving the city's problems with air pollution the classroom environment probably would look quite a bit different. Students could work in groups and divide up the various tasks that need to be accomplished to solve this real-world issue. Perhaps you would find a group of students looking through newspapers to gather data related to the local weather, while another group searched the Internet for information about air pollution, as other students collected data about the city's population. These students would simultaneously be engaged in science, mathematics, and reading. They would also be utilizing their technical skills and search skills as well as exercising their skills in social communication (p.2) [17]" This is also an indication of an interdisciplinary approach to authentic learning environments.

From this point, ***building interdisciplinary perspective*** was emerged as another category. In early STEM lessons, the focus is on an interdisciplinary application. For example, while the main discipline in the final theme is mathematics, there are also

objectives in engineering and science disciplines during product development. That is, students learned to make use of two or more disciplines in solving a problem. This also shows that students should have different aspects of knowledge for their future lives which will require to use more than one field of information. So, early STEM lessons provided this to students in early ages. For example, students stated during interivew that:

S8: I use [information about Mars planet] in science class, we do about planets [in science lessons]. So it helps me with other lessons (in Turkish: [Mars gezegeni ile ilgili bilgileri] fen dersinde kullanıyorum, gezegenlerle ilgili yapıyoruz ya. Diğer derslerime yardımcı oluyor yani)

S3: Learning [the pulley system] has made a great contribution to me. Because I used a pulley system in our English Project (in Turkish: [makara sistemini]öğrenmem bana çok iyi katkı sağladı. Çünkü ingilizce projemizde makara sistemi kullanmıştım)

Teacher: ... We did the Scratch program on the computer. For example, we could have been it to all lessons. According to objectives, students learned both Scratch and have been repeating the local administrations of that week on social studies class. Every week we give different lessons, so it is fully maintained (in Turkish: ...Bilgisayarda Scratch programını yaptık. Mesela bütün derslere yaydık biz onu. Kazanım olarak hem Scratch'i öğreniyor, hem de atıyorum o haftanın yerel yönetimlerini sosyalden tekrar etmiş oluyor. Her hafta farklı derslere verdiğimiz için kalıcılığı tam anlamıyla sağlanmış oluyor)

S11: For example, in mathematics, I have calculated dimensions. Then there is Science. Normally there are no germs, but we're trying to make germ killers. I did something like that in our English project. So we used science in most places of our product (in Turkish: Mesela matematik olarak, hesapladım boyutlarını. Ondan sonra Fen bilimleri var. Normalde mikrop yok ama mikrop öldüren aletler yapmaya çalıştık. İngilizce projemizde de öyle bir şey yapmıştım. Yani çoğu yerde fen dersinde de kullandık)

At this point, interdisciplinarity had an important place in early STEM lessons as well as in authentic learning, because one of the characteristics of authentic learning is the interdisciplinarity [17]. Interdisciplinary perspective is also one of the authentic learning elements and according to this notion, subject matters are not related only single discipline, it requires knowledge of more than one discipline, and students should act by

considering interdisciplinary concepts [16]. For example, in the the last theme (My World of Imagination), students focused on the mathematical concepts and they made some designs according to isometric patterns, created different geometric shapes with the same circumference and also experienced how to do measurements. While doing this, they also relate their knowledge with other disciplines like engineering and arts by discussing how artistic periods and styles influence product and architectural design. Beyond this, interdisciplinarity also takes part among the general objectives of the STEM: Integrated teaching framework [4]. So, learning environment should be interdisciplinary and also multidisciplinary that is, real world conditions requries multiple perspectives and disciplines, and in order to adapt the real life, students should experience these skills during their education lives. That is why; authentic learning environment should be supplied them for easier adaptation to real world.

The category of ***experience real world STEM applications*** also supports above statements. In other words, making connections with the real-life situations in learning process is important since transfer of knowledge can be handled through authentic experiences as stated earlier. Beyond this, while experiencing real world STEM applications, students also ***built STEM knowledge and skills.*** Also, during early STEM implementations, students were actively involved in learning process by interacting, communicating or exploring to solve a real-life problem and in this time, they structured some STEM knowledge and experienced STEM skills with scientific and engineering practices:

S2: For example, I learned how other energies can be used without using energy. I learned how to turn the reel with water (in Turkish: Mesela enerji kullanmadan başka enerjilerin nasıl olabileceğini öğrendim. Su enerjisiyle nasıl makara döndürebileceğimizi öğrendim)

S7: The command, the algorithm, the program [said by looking at the portfolio]. We learned by researching what these are (in Turkish: Komut, algoritma, program [portfolyoya bakarak söyledi]. Bunların ne olduğunu araştırarak öğrendik)

From the above quotations, we see that students learned different concepts which they may use in their future daily and professional lives. So, being aware of such concepts at an early ages make it easier to adapt to most conditions in their lives. Authenticity was also took place as the characteristics of situated learning environment [69] and in situated learning, knowledge is also used in situations that reflect real-life conditions.

From these aspects, there is also inconsistency between the information obtained from schools and the learning process in real life [17]. Therefore, students can not make any connections between their school learning and real-life situations, that is, they can not transfer their knowledge into real-life. Authentic learning provides an opportunity to bring real-life experiences into classroom. So, students can make any conncetions for their learnings and early STEM lessons provided this by also developing STEM awareness. Namely, students took an authentic problem during the whole process and they tried to solve it by their own and also by using various skills that they may use in daily life. In this manner, learning was ensured in a meaningful way.

To sum up, for this theme we can understand ***the spatial importance for STEM learning.*** That is, STEM education should be related with real-life in an authentic environment. In this way, learning can be transferred and become meaningful for students.

4.2.3 Essential Role of Early STEM Education Upon Students' Authentic Learning Experiences

In early STEM lessons, students gained an interdisciplinary knowledge by focusing on a real-life problem and while trying to solve this problem, some abilities were needed such as problem solving, communicating, searching, criticizing the information, critical thinking etc. which are the 21st century skills. In this manner, authentic learning experiences had an important place on this process. So, this qualitative ethnographic case study was an opportunity to explore the students' authentic learning experiences through early STEM lessons more deeply.

From this perspective, an authentic problem was presented to students and they created various solutions from different aspects. According to Renzulli et al. [93], the problem should be open-ended and students should select the way for solutions by their own. In the same way, Maina [94] and Callison and Lamb [95] also stated that authentic learning should be student centered. Therefore, early STEM lessons have an essential role on this process and the emerged categories for this theme are: gain hands-on STEM learning experiences, developing physical attributes, developing personal attributes.

The category, ***gain hands-on STEM learning experiences*** is about using tools while constructing the products, thinking critically while determining the best solutions,

evaluating the created product in different aspects and so on. That is, during early STEM lessons, students' ***physical and personal attributes*** were improved. For example;

S12: My skills such as shaping dough, modeling, coding on a computer have improved (in Turkish: Hamurdan şekil yapma, maket yapma, bilgisayarda kodlama yapma gibi becerilerim gelişti)

S1: He made me harder. He has developed my other skills (in Turkish: Beni daha çalışkan yaptı. Diğer becerilerimi geliştirdi)

S10: So I learned how to make a project, how to research it (in Turkish: Proje nasıl yapılır, araştırma nasıl yapılır onları öğrendim)

S13: It is difficult to adjust the angle of the roller. And you do not know where to pour the water because the cap is small (in Turkish: Silindirin açısını ayarlamak zordur. Suyu nereye akacağınızı bilmiyorsunuz çünkü kapak küçük)

S9: [it] was more about thinking. I learned to share with my friends (in Turkish: Düşünmekten daha fazlasıydı. Arkadaşlarımla paylaşmayı öğrendim)

The above quotations indicates that since students are in earlier ages, creating such products in early STEM lessons has positive effect on the improvement of students' motor skills. Also, since they thought on the solutions by criticizing them while creating these products, their mental abilities were also developed. The best examples for these situations were seen on the answers of students for the last interview question: …with the help of the information you have, can you suggest a problem that exists in your environment and that you want to solve?

While answering this question, students summarized the whole process of early STEM program and they determined a real-life problem that is important to solve for them. They have conducted ideas on why the problem is important and which steps can they take to solve the problem. While doing this, they presented authentic learning experiences. Namely, the problem they addressed was related to both real life and their interests, they presented also their reasoning for suggestions for example, one student (S11) stated that *"...I forbid benzines. I make cars that work with electric. I do something like this to prevent environmental pollution (in Turkish: Benzini yasaklarım. Elektrikli araba yaparım. Çünkü çevre kirliliğini önlemek için böyle bir şey yaparım)"*

So, students engaged in complex responsibilities and showed higher order thinking skills which are also the characteristics of authentic learning experiences [16], [17]. That is why; early STEM lessons have an important role and effect on students' authentic learning experiences.

4.3 Limitations of the Study

This qualitative ethnographic case study was conducted to investigate students' authentic learning experiences in early STEM lessons. Sample of the study consisted of 14 participants in total included one classroom teacher and one class of 4^{th} grade students who attend early STEM lessons. The classes meet at a standard length of time each week for early STEM lessons as 45 minutes. Although the early STEM program lasted eight months in total, the period of the study was limited by the eight weeks. Namely, only for one theme of the program observations were made by the researcher and informations were gathered for the other processes (the first three themes) through student and teacher intervews. Additionally, the private elementary school selected as the research site since the classroom teacher of this class have an experience and knowledge on early STEM program. The number of participants are few and they represents only that group. Beyond this, the theoretical approach for this present study was handled in a narrow focus, so the research results cannot be generalized as the nature of qualitative studies. On the other hand, since the data were analyzed in a deeper way, the findings represent a pathway to inform future researchers who study on authentic learning experiences within STEM education.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The connections between the three themes and the research questions were revealed and interpretations of the data collected through the field notes collected during classroom observations, transcripts from the interview with the students and the classroom teacher. The first theme, authenticity vital role in early STEM education, was about the pointing out real-world problems, students' skills on authenticity, engagement of students in social learning and reflection of learning into real-life situations. Second theme, early STEM effectiveness in authentic environment, represented the STEM careers, STEM applications-awareness-knowledge and skills in an interdisciplinary perspective. The last theme, essential role of early STEM education upon students' authentic learning experiences, also provided an insight on students' personal and physical attributes as well as scientific and engineering practices.

The results of the study showed that how STEM education has a role in authentic learning experiences in early grades and in what way students' STEM literacy was increased in this age of groups. The literature also suggests that learning is carried out with authentic tasks students' interest and motivation. Also, by connecting the task with the real life situation, the transfer of the authentic learning has been ensured. In this manner, it can be also concluded that authentic learning experiences demonstrate an awareness of the events and practices that the learners engage with in their own communities. In other words, students produced a product and they shared it with the audience and at the end of the whole process, their higher order thinking, problem solving, analyzing or interpreting skills developed.

Figure5.1 Students' products examples for the My World of Imagination Theme of early STEM program

Beyond this, authentic learning was configured as 10 authentic learning elements [81] and during early STEM lessons for 8 weeks and in interviews, these elements were observed and determined. The elements of *real-world relevance* and *ill-defined problem* were pointed in the first week of the early STEM lessons which APKS was introduced. That is, APKS is a real-life related and ill-defined problem with multiple solutions and so authenticity was ensured for these elements. The elements of *sustained investigations* and *multiple sources and perspectives* referred the fact finding and ideation phases of the program. Namely, during the fact finding phase, students conducted studies and found multiple answers for the questions that were needed to solve the problem. Also, in this process, they used multiple sources to reach the answers such as parents, internet, friends etc. In the whole process, students work with group and *collaboration* was supplied. Students also had a choice of their decisions for solution ways and they were able to reflect and evaluate their own learnings in an authentic context (metacognition). Encouraging of the students in an authentic learning environment with early STEM activities also supplied with an *interdisciplinary perspective*. At the end of the 8 weeks period, students *presented their products* in a valuable way and *multiple outcomes* were emerged from authentic activites (see figure 5.1)

Finally, the *(integrated) assessment* of these products and also students' works for the whole process was evaluated in general. That is, instead of just evaluating the product, an evaluation method was used that covers the entire process: which was the students' engagement during the lessons, prepared portfolios which summarize the whole process, and also presentations of the products by the students.

To sum up, the aim of this ethnographic case study was to investigate the students' authentic learning experineces and through collected data from classroom observations

and interview transcripts, it can be stated that early STEM program has an important role on authentic learning tasks and provides better understanding on students' authentic learning experiences.

5.2 Recommendations

In this present study, learning environment was situated in an authentic manner and classroom teacher had an experience on STEM applications before implemented this program to students. So, at the point of implementation of STEM activities, it is very important for teachers to be experienced. That is why; teacher training programs should be prepared especially for primary levels, that is, for pre-school and elementary teachers. Because implementing STEM education in early grades has effective results on students'learning and skills. So, the present ethnographic case study conducted with 4^{th} grade students and during the interview, one of the students said that:

Teacher: How do you see any way to do all of this?(in Turkish: Bütün bunları [ürün oluştura süreci] yapmak için nasıl bir yol izlersin peki?)

S11: At first I said to look at the core of the Earth or find the appropriate conditions for research. It triggers another burst when there is an explosion in the core. Now it starts to trigger, because there are earthquakes, tsunamis. So I have to grow up as soon as possible (in Turkish: İlk başta Dünya'nın çekirdeğine bakarım dedim ya araştırırım uygun koşulları bulurum. Çekirdekte bir patlama olduğunda başka bir patlamayı tetikler. Şu anda da tetiklemeye başladı, çünkü depremler oluyor, tsunamiler. O yüzden benim bir an önce büyümem lazım)

From the last sentence of students' sayings it can be seen that students are more curious about their environments than older ones and so their motivation and interests should be guided correctly. In this manner, studies should be carried out that can lead students to areas of interest at an early age. Therefore, more importance should be given on STEM education in early grades to be able to solve authentic problems outside the classroom to determine students' views and also dreams.

Similarly, in this present study students' views were taken after the program was implemented. So, their views can be also taken before the implementation of Early STEM lessons. In this way, the developments and changes in the students can be observed and determined more clearly.

At this point, school curricula were changed and STEM was integrated but it took place from the 4th grades' program. Therefore, in order to increase the number of students' in STEM occupations and with STEM skills, STEM should be integrated into school curricula from pre-school level and more programs, as Early STEM Program, should be organized and applied in all schools, both public and private. In this manner, classroom teacher training programs should be also prepared to implement STEM education in earlier grades as stated earlier. From this perspective, Erdogan and Stuessy [71] stated on learning environment that, "[for better learning environment], community leaders may especially encourage teachers to take responsibilities by (a) communicating, (b) supporting, (c) giving more power, (d) involving in decision-making process, and (e) appreciating them (p.87) [71]" Therefore, teachers should be informed and well experienced while implementing a program and this study provides an insight on addressing STEM education and promoting STEM applications in an authentic learning environment, especially for early grades.

Beyond this, there is only one teacher, called as classroom teacher, for a classroom and the teacher gives necessary information to students in all areas. For this reason, their curriculum is more flexible than middle and high school levels. So, these teachers can apply the STEM activities in an easier way than upper grades. Since all teachers have entered a single classroom, they can make arrangements for other courses and time management in a more comfortable way.

REFERENCES

[1] Tippett, C. D. and Milford, T. M., (2017). "Findings from a pre-kindergarten classroom: Making the case for stem in early childhood education", International Journal of Science and Mathematics Education, 15(1): 67-86.

[2] Aydeniz, M., Cakmakcı, G., Cavas, B., Ozdemir, S., Akgunduz, D., Corlu, M. S. and Oner, T., (2015), STEM eğitimi Türkiye raporu: Günün modası mı yoksa gereksinim mi? http://www.aydin.edu.tr/belgeler/IAU-STEM-Egitimi-Turkiye-Raporu-2015.pdf, 20 Mayıs 2018.

[3] Corlu, M. S., Capraro, R. M. and Capraro, M. M., (2014). "Introducing STEM education: Implications for educating our teachers in the age of innovation", Education and Science, 39(171): 74-85.

[4] Corlu, M. S., (2017). STEM: Bütünleşik öğretmenlik çerçevesi [STEM: Integrated teaching framework]. In Callı, E., Corlu, M. S. & Erdoğan, N. (Eds). STEM Kuram ve Uygulamaları (English: *STEM: Practices and Theories*). Pusula Yayıncılık ve İletişim: İstanbul, Turkey.

[5] Capraro, R. M., Capraro, M. M., Scheurich, J., Jones, M., Morgan, J., Huggins, K. S., Corlu, M. S., Younes, R. and Han, S., (2016). "The impact of sustained professionel development in STEM project based learning on district outcome measures", The Journal of Educational Research, 0(0): 1-16.

[6] Corlu, M. S., (2014). FeTeMM eğitimi makale çağrı mektubu [Call for STEM education research in the Turkish context]. *Turkish Journal of Education, 3*(1), 4-10.

[7] Corlu, M S., Burlbaw, L. M., Capraro, R. M., Han, S. and Corlu, M. A., (2010). "The Ottoman palace school and the man with multiple talents, Matrakçı Nasuh", Journal of the Korea Society of Mathematical Education Series D: Research in Mathematical Education, 14(1): 19-31.

[8] Corlu, M. S., Capraro, R. M. and Capraro, M. A., (2015). "Investigating the mental readiness of preservice teachers for integrated teaching", Online Journal of Educational Sciences, 7(1): 17-28.

[9] MEB, (2015). *PISA 2012 Ulusal Nihai Raporu*. Millî Eğitim Bakanlığı, Ölçme, Değerlendirme ve Sınav Hizmetleri Genel Müdürlüğü, Ankara.

[10] Furner, J. M. and Kumar, D. D., (2007). "The mathematics and science integration argument: A stand for teacher education", Eurasia Journal of Mathematics, Science & Technology Education, 3(3): 185-189.

[11] Wang, H. H., (2012). A new era of science education: Science teachers‘ perceptions and classroom practices of science, technology, engineering, and mathematics (STEM) integration, Doctoral Thesis, MinnesotaUniversity, Minnesota.

[12] Sanders, M., (2009). “STEM, STEM Education, STEMmania”, Technology Teacher, 68(4): 20-26.

[13] Gülhan, F. and Şahin, F., (2016). “The effects of science technology engineering math (STEM) integration on 5th grade students’ perceptions and attitudes towards these areas”, International Journal of Human Sciences, 13(1): 602-620.

[14] Ayar, M. C. and Yalvac, B., (2010). “A sociological standpoint to authentic scientific practices and its role in school science teaching”, Ahi Evran Univ. Kirsehir Journal of Education (KEFAD), 11(4): 113-127.

[15] Chinn, C. A. and Malhotra, B. A., (2002). “Epistemologically authentic reasoning in schools: A theoretical framework for evaluating inquiry tasks”, Science Education, 86: 175-218.

[16] Lombardi, M. M. and Oblinger, D. G., (2007). “Authentic Learning for the 21st Century: An overview”, Educause: 2.

[17] Mims, C., (2003). “Authentic Learning: A practical introduction & guide for implementation Meridian”, A Middle School Computer Technologies School, 6(1): 1-12.

[18] Apedoe, X., Walker, S. and Reeves, T., (2006). “Integrating inquiry-based learning into undergraduate geology”, Journal of Geoscience Education, 54: 414–421.

[19] Milson, A. J., (2002). “The Internet and Inquiry Learning: Integrating Medium and Method in a Sixth Grade Social Studies Classroom”, Theory & Research in Social Education, 30: 330–353.

[20] Eshach, H. and Fried, M. N., (2005). “Should science be taught in early childhood?”, Journal of Science Education and Technology, 14(3): 315–336.

[21] Patrick, H., Mantzicopoulos, P., Samarapungavan, A. and French, B. F., (2008). “Patterns of young children’s motivation for science and teacher-child relationship”, The Journal of Experimental Education, 76(2): 121–144.

[22] Saçkes, M., Trundle, K. C., Bell, R. L. and O’Connell, A. A., (2011). “The influence of early science experience in kindergarten on children’s immediate and later science achievement: Evidence from the early childhood longitudinal study”, Journal of Research in Science Teaching, 48(2): 217–235.

[23] Lindahl, B., (2007). “A longitudinal study of students’ attitudes towards science and choice of career”, Annual meeting of the National Association for Research in Science Teaching, New Orleans, LA.

[24] Bybee, R., (2010). “Advancing STEM education: A 2020 vision”, Technology and Engineering Teacher, 70(1): 30-35.

[25] Salinger, G. and Zuga, K., (2009). “Background and history of the STEM movement. In ITEEA (Ed.)”, The Overlooked STEM Imperatives: Technology and Engineering (pp. 4-9). Reston, VA: ITEEA.

[26] Atkinson, R. D. and Mayo, M. J., (2010). "Refueling the US innovation economy: Fresh approaches to science, technology, engineering and mathematics (STEM) education", The Information Technology & Innovation Foundation.

[27] Barker, B. S., Nugent, G. and Grandgenett, N. F., (2014). "Examining fidelity of program implementation in a STEM-oriented out-ofschool setting", International Journal of Technology and Design Education, 24(1): 39-52.

[28] Bryan, R. R., Glynn, S. M. and Kittleson, J. M., (2011). "Motivation, achievement, and advanced placement intent of high school students learning science", Science Education, 95(6): 1049-1065.

[29] Sha, L., Schunn, C. and Bathgate, M., (2015). "Measuring choice to participate in optional science learning experiences during early adolescence", Journal of Research in Science Teaching, 52(5): 686- 709.

[30] Brown, J., Brown R. and Merrill, C., (2012). "Science and technology educators' enacted curriculum: areas of possible collaboration for an integrative STEM approach in public schools", Technology Teacher, 71(4): 30-34.

[31] U.S. Department of Education, Report of the Academic Competitiveness Council, http://coalition4evidence.org/wp-content/ uploads/ ACC-report-final.pdf, 17 Mart 2018.

[32] Furner, J. M. and Kumar, D. D., (2007). "The mathematics and science integration argument: A stand for teacher education", Eurasia Journal of Mathematics, Science & Technology Education, 3(3): 185-189.

[33] Hernandez, P. R., Bodin, R., Elliott, J. W., Ibrahim, B., Rambo Hernandez, K. E., Chen, T. W. and de Miranda, M. A., (2014). "Connecting the STEM dots: measuring the effect of an integrated engineering design intervention", International Journal of Technology and Design Education, 24(1): 107-120.

[35] Morrison, J. and Bartlett, B., STEM as a curriculum: An experimental approach, http://www.labaids.com/docs/stem/EdWeekArticleSTEM.pdf, 14 May 2018.

[36] Dyer, R. R., Reed, P.A. and Berry, R. Q., (2006). "Investigating the relationship between high school technology education and test scores for algebra 1 and geometry", Journal of Technology Education, 17(2): 7-17.

[37] Meyrick, K. M., (2011). "How STEM education improves student learning", Meridian K12 School Computer Technologies Journal, 14(1): 1-6.

[38] Wai, J., Lubinski, D., Benbow, C. P. and Steiger, J. H., (2010). "Accomplishment in Science, Technology, Engineering, and Mathematics (STEM) and its relation to STEM educational dose: A 25 year longitudinal study", Journal of Educational Psychology, 102(4), 860871.

[39] Rockland, R., Bloom, D. S., Carpinelli, J., BurrAlexander, L., Hirsch, L. S. and Kimmel, H., (2010). "Advancing the "E" in K-12 STEM education", Journal of Technology Studies, 36(1): 5364.

[40] Thompson-Krug, M. E., (2014). The effects of authentic learning experiences on female's students' perceptions of science and confidence in attaining a STEM career, Master Thesis, Montana State University, Bozeman/Montana.

[41] Honey, M., Pearson, G. and Schweingruber, H., (2014). STEM integration in K-12 education: Status, prospects, and an agenda for research, National Academy of Engineering and National Research Council, The National Academies Press, Washington D.C.

[42] Little, R., Poth, R., Gilbert, R. and Barger, M., (2005), "Adapting the engineering design process for elementary education applications", 2005 Annual Conference, June 2005, Portland, Oregon.

[43] Corbett, K. S. and Coriell, J. M., (2014). "STEM explore, discover, apply – A middle school elective (curriculum exchange)", 2014 ASEE Annual Conference, 15-18 June 2014, Indianapolis, Indiana.

[44] Çavaş, B., Bulut, Ç., Holbrook, J. and Rannikmae, M., (2013). "Fen eğitimine mühendislik odaklı bir yaklaşım: Engineer projesi ve uygulamaları", Fen Bilimleri Öğretimi Dergisi, 1(1): 12-22.

[45] Yamak, H., Bulut, N. and Dündar, S., (2014). "5. sınıf öğrencilerinin bilimsel süreç becerileri ile fene karşı tutumlarına FeTeMM etkinliklerinin etkisi", GEFAD/GUJGEF, 34(2): 249-265.

[46] Tamassia, L. and Frans, R., (2014). "Does integrated science education improve scientific literacy", Journal of the European Teacher Education Network, 9: 131-141.

[47] Erdoğan, N., Corlu, M. S. and Capraro, R. M., (2013). "Defining innovation literacy: Do robotics programs help students develop innovation literacy skills?", International Online Journal of educational Sciences, 5(1): 1-9.

[48] Kennedy, T. J. and Odell, M. R. L., (2014). "Engaging students in STEM education", Science Education International, 25(3): 246-258.

[49] Balat, G. U. and Günşen, G., (2017). "Okul öncesi dönemde STEM yaklaşımı", The Hournal of Academic Social Science, 5(42): 337-348.

[50] Sullivan, A. and Bers, M. U., (2015). "Robotics in the early childhood classroom: learning outcomes from an 8-week robotics curriculum in pre-kindergarten through second grade", International Journal of Technology and Design Education, 26(1): 3-20.

[51] Laboy-Rush, D., Integrated STEM education through project-based learning, http://www.rondout.k12.ny.us/UserFiles/Servers/Server_719363/File/12-13/STEM/STEM-White-Paper%20101207%20final%5B1%5D.pdf, 7 April, 2011.

[52] Brown, R., Brown, J., Reardon K. and Merrill, C., (2011). "Understanding STEM: Current perceptions", Technology and Engineering Teacher, 70(6): 5-9.

[53] Russell, S. H., Hancock, M. P. and McCullough, J., (2007). "Benefits of undergraduate research experiences", Science, 316: 548-549.

[54] Russell, T., (1999). "The challenge of change in teaching and teacher education", In: J.R. Baird, (1999) Editor, Reflecting, teaching, learning: Perspectives on educational improvement, Hawker Brownlow Education, Cheltenham. Victoria, Australia: 219-238.

[55] Lind, K., (1998). “Science in Early Childhood: Developing and acquiring fundamental concepts and skills”, Early Childhood Science, Matematics and Tecnology Education, February 6-8.

[56] Mantzicopoulos, P., Patrick, H. and Samarapungavan, A., (2008). “Young children’s motivational beliefs about learning science”, Early Childhood Research Quarterly, 23: 378- 394.

[57] Dejarnette, N.K., (2012). “America’s children: Providing early exposure to STEM (Science, Technology, Engineering and Math) initiatives”, Education, 133(1): 77-84.

[58] Kier, M. W., Blanchard, M. R., Osborne, J. W. and Albert, J. L., (2014). “The development of the STEM career interest survey (STEM-CIS)”, Research in Science Education, 44(3): 461-481.

[59] MEB., (2017). Fen Bilimleri Dersi Öğretim Programı. İlkokul ve Ortaokul 3, 4, 5, 6, 7 ve 8. Sınıflar. [Science Education Curriculum. Primary and Secondary schools (3, 4, 5, 6, 7 and 8th grades)], Ankara.

[60] Leuchter, M., Saalbach, H. and Hardy, I., (2014). “Designing science learning in the first years of schooling. An intervention study with sequenced learning materials on the topic of ‘floating and sinking’”, International Journal of Science Education, 36(10): 1751–1771.

[61] Roth, W.-M., Goulart, M. I. M. and Plakitsi, K., (2013). Science education during early childhood: A cultural historical perspective, Dordrecht, The Netherlands: Springer.

[62] Trundle, K. and Saçkes, M., (2012). “Science and early education. In R. Pianta (Ed.)”, Handbook of early childhood education (pp. 240–258), New York, NY: Guilford.

[63] Baran, E., Canbazoğlu-Bilici, S. and Mesutoğlu, C., (2015). “Fen, teknoloji, mühendislik ve matematik (FeTeMM) spotu geliştirme etkinliği”, Araştırma Temelli Etkinlik Dergisi (ATED), 5(2): 60-69.

[64] Yıldırım, B. and Altun, Y., (2015). “STEM eğitim ve mühendislik uygulamalarının fen bilgisi laboratuar dersindeki etkilerinin incelenmesi”, El-Cezerî Fen ve Mühendislik Dergisi, 2(2): 28-40.

[65] Adıgüzel, T., Ayar, M. C., Corlu, M. S. ve Özel, S. (2012). “Fen, teknoloji, mühendislik ve matematik (FeTeMM) eğitimi: Disiplinlerarası çalışmalar ve etkilişimler”, X. National Congress on Science and Mathematics Education, 27-30 June 2012, Niğde, Turkey.

[66] Milli Eğitim Bakanlığı, (2016). STEM Eğitimi Raporu [STEM education report], Ankara.

[67] Serbest, A. H., (2005). “Vizyon 2023 teknoloji öngörü projesi: Eğitim ve insane kaynakları sonuç raporu ve strateji belgesi”, Türkiye Bilimsel ve Teknik Araştırma Kurumu, Ankara, Türkiye.

[68] Resnick, L., (1996). “Situated rationalism: The biological and cultural foundations for learning”, Prospects, 26(1): 37-53.

[69] Herrington, J. and Oliver, R., (2000). “An instructional design framework for authentic learning environments”, Educational Technology Research and Development, 48(3): 23-48.

[70] Marshall, S. P., (2010). “Re-imagining specialized STEM academies: Igniting and nurturing decidedly different minds, by design”, Roeper Review, 32(1): 48-60.

[71] Erdogan, N. and Stuessy, C. L., (2015). “Modeling successful STEM high schools in the United States: An ecology framework”, International Journal of Education in Mathematics, Science and Technology, 3(1): 77-92.

[72] Martin B. and Michael R., (2006). “Towards a More Authentic Science Curriculum: The contribution of out-of-school learning”, International Journal of Science Education, 28(12): 1373-1388

[73] Aina, J. K., Aboyeji, O. O. and Aboyeji, D. O., (2015). “An investigation of authentic learning experience of pre-service teachers in a Nigerian college of education”, European Journal of Research and Reflection in Educational Sciences, 3(4): 54-63.

[74] Anwari, I., Yamada, S., Unno, M., Saito, T., Suwarma, I. R., Mutakinati, L. and Kumano, Y., (2015). “Implementation of authentic learning and assessment through stem education approach to ımprove students' metacognitive skills”, K-12 STEM Education, 1(3): 123-136.

[75] Burton, K., (2011). “A framework for determining the authenticity of assessment tasks: Applied to an example in law”, Journal of Learning Design, 4(2): 20–28.

[76] Rinke, C. R., Gladstone-Brown, W., Kinlaw, C. R. and Cappiello, J., (2016). “Characterizing STEM teacher education: Affordances and constraints of explicit STEM preparation for elementary teachers”, *School Science and Mathematics, 116*(6): 300-309.

[77] Capraro, R. M. and Han, S., (2014). “STEM the education frontier to meet 21st century challenges”, Middle Grades Research Journal, 9(3): 15-18.

[78] Stohlmann, M., Moore, T. J. and Roehrig, G.H., (2012). “Considerations for teaching integrated STEM education”, Journal of Pre-College Engineering Education research 2(1): 28-34.

[79] Carr, R. L. and Strobel, J., (201). “Integrating engineering into secondary math and science curricula: A course for preparing teachers”, 1st Integrated STEM Education Conference (ISEC), April 2017, Ewing, NJ.

[80] Rule, A. C., (2006). “Editorial: The Components of Authentic Learning”, Journal of Authentic Learning, 3(1): 1-10.

[81] Lombardi, M. M., (2007). Authentic learning for the 21st century: An overview, Educase, https://www.educause.edu/ir/library/pdf/ELI3009.pdf, 2 April 2018.

[82] Creswell, J. W., (2007). Qualitative Inquiry & Research design: Choosing among Five Approaches, Second edition, Thousand Oaks, CA: Sage.

[83] Savin-Baden, M. and Howell Major, C., (2013). Qualitative research: The essential guide to theory and practice, New York: Routledge. ISBN: 978-0415674782.

[84] Denzin, N. K. and Lincoln, Y. S. (Eds.)., (2008). Collecting and interpreting qualitative materials, Second edition, Sage, Los Angeles.

[85] Holstein, J. A. and Gubrium, J. F., (2011). The constructionist analytics of interpretive practice. In N. K. Denzin, & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (pp.341-357), Thousand Oaks, CA: Sage.

[86] Strobel, J., Wang, J., Weber, N. R. and Dyehouse, M., (2013). "The role of authenticity in design-based learning environments: The case of engineering education", Computers & Education, 64: 143–152.

[87] Aşık, G., Doğança Küçük, Z., Helvacı, B. and Çorlu, M. S., (2017). "Integrated teaching project: A sustainable approach to teacher education", Turkish Journal of Education, 6(4): 200-215.

[88] Yin, R. K., (2013). Case study research: Design and methods, Fifth edition, Thousand Oaks, CA: Sage.

[89] Bybee, R., (1993). Instructional model for science education in developing biological literacy, Colorado Springs, CO: Biological Sciences Curriculum Studies.

[90] Denzin, N. K., (1970). The Research Act: A Theoretical Introduction to Sociological Methods, Aldine, Chicago.

[91] Charmez, K., (2006). Constructing grounded theory: A practical guide through qualitative analysis, CA: Sage, Thousand Oaks.

[92] Garrett, L., Huang, L. and Charleton, M. C., (2016). "A framework for authenticity in the mathematics and statistics classroom", The Mathematics Educator, 25(1): 32-55.

[93] Renzulli, J. S., Gentry, M. and Reis, S. M., (2004). "A time and a place for authentic learning", Educational Leadership, 62(1): 73-77.

[94] Maina, F. W., (2004). "Authentic learning: Perspectives from contemporary educators", Journal of Authentic Learning, 1(1): 1-8.

[95] Callison, D. and Lamb, A., (2004). "Key words in instruction: Authentic learning", School Library Media Activities Monthly, 21(4): 34-39.

[96] Piaget, J., (1954). The construction of reality in the child, Basic Books, New York, NY.

[97] Tran, D. and Dougherty, B. J., (2014). "Authenticity of mathematical modeling", Mathematics Teacher, 107(9): 672–678.

[98] Harris, C. and Marx, R., Authentic tasks, http://www.education.com/reference/article/authentic-tasks/, 17 January 2018.

[99] Scott, J., (2000)." Authentic assessment tools. In R. L. Custer (Ed.), J. W. Schell, B. McAlister, J. Scott, and M. Hoepfl. *Using authentic assessment in vocational education*. Information Series No. 381 (pp. 40-55)", Eric Document Reproduction Service No. Ed 440 293.

[100] Kramarski, B., Mevarech, Z. R. and Arami, M., (2002). "The effects of metacognitive instruction on solving mathematical authentic tasks", Educational Studies in Mathematics, 49(2): 225-250.

[101] Vygotsky, L. S., (1978). Mind in society: The development of higher physiological processes, Revised Edition, MA: Harvard University Press. Cambridge.

[102] Lee, H. and Songer, N. B., (2003). "Making Authentic science accessible to students", International Journal of Science Teaching, 25(8): 923-948.

[103] Doğança Küçük, Z., (2017). BAU erken STEM Program Kitabı, İstanbul: Uğur Hazırlık Eğitim ve Yayıncılık A.Ş.

[104] Angers, J. and Machtmes, K. L., (2005). "An Ethnographic-Case Study of Beliefs, Context Factors, and Practices of Teachers Integrating Technology", The Qualitative Report, 10 (4): 771-794.

APPENDIX-A

INFORMED CONSENT FORM FOR EARLY STEM PROGRAM DEVELOPERS

The purpose of this form is to get the permission of early STEM program developers to conduct this study for master thesis or not.

This study, conducted by Şefika Girgin; a graduate student in Yıldız Technical University, is about to observe and comment on how STEM is implemented in classrooms as a natural environment and how students are engaged in this process. The research purpose and questions will focus on the culture of the STEM lesson.

The applications to be made in the research process are as follows:

- In this study, researcher will collect ethnographic data that is totally different from collected data in early STEM: Integrated Teaching Project.
- Students will be observed once a week in early STEM lessons for a total of 8 weeks in a campus of private school in Istanbul.
- During the observation, researcher behave as non-participant and just will identify and explore the culture of early STEM lessons in the campus of the school.
- No conclusion will be drawn on the effectiveness or applicability of the program. The observations and interviews with the students will be conducted just to explore the authentic learning experiences of students within the learning environment in early STEM lessons.
- Interviews will be done with some of the students who volunteered to participate from the class (13 students in total).The location will be on the campus for the convenience of the students and the time will be arranged after the daily school hours to avoid any disruption to instruction.
- Interviews will be audio-taped by getting the permission of the students before the interview orally. The tapes will be kept confidential and only kept in the computer of the researcher.
- Consent will be taken from teacher and students, also school administrator for observation and interviews.
- The collected data from observation and interviews will be kept by the researcher and will be shared while maintaining confidentiality with program developers.

- At the conclusion of this research, a copy of the results will be provided to BAUSTEM.

What are the risks involved in this study?

The risks associated in this study are minimal. Confidentiality will be maintained by keeping th names of teacher and students as secret in the stored data. All stored data and electronic devices will be stored and available to the researcher and advisor, Prof.Dr. Bayram Coştu, and program developers, BAUSTEM center.

What are the possible benefits of this study?

There are greater academic benefits include access for educators to valuable information provided by the participants that may contribute to early STEM lessons. Also, the collected data will be used for academic studies as proceedings or academic articles with a possible collaboration with BAUSTEM.

Signature

Please be sure you have read the above information, asked questions and received answers to your satisfaction. You will be given a copy of the consent form for your records. By signing this document, you certify you give permission to enter early STEM classroom as researcher and to collect data in the early STEM program that you developed.

Name and Surname: Assist. Prof. Dr. Zerrin DOĞANÇA KÜÇÜK

Signature of Assistant-Director of BAUSTEM:

Notes

1. Please sign two copies.

2. Keep one copy for your records

3. Return your consent to the researcher

APPENDIX-B

PERMISSION LETTER GRANTED BY PRINCIPAL TO CONDUCT STUDY

Dear Principal,

I am writing to you in regards to asking your permission to work with one of your teacher on one campus and observing the early STEM lessons during 8 weeks. I am a master student at Yıldız Technical University and I am under the advisement of Prof. Dr. Bayram Coştu. I am currently proposing to conduct a qualitative study in which I use a STEM lesson in 4th grade classroom for a case study.

I am proposing a qualitative ethnographic case study, to explore the culture of a STEM lesson and so I am going to observe a classroom to investigate students' authentic learning experiences within the learning environment in STEM lessons. The goal of this study is to observe and comment on how STEM applications are implemented in classrooms as a natural environment and how students are engaged in this process.

I would like to share with you my intentions for the study:

1. I get it approved by BAUSTEM.
2. I ask and confirm a teacher who give lesson in 4th grade classroom
3. I observe the class in action (one lesson hour- only early STEM lessons). I would be coming once a week for early STEM lessons for about 8 weeks.
4. I will conduct interviews with some of your students who volunteered to participate from the class (13 students in total). Each of the interviews will take approximately 15-20 minutes. The location will be on the campus for the convenience of the students and the time will be arranged after the daily school hours to avoid any disruption to instruction.
5. You will be asked to sign a consent to approve this study and you will return this form to me and will get a copy for yourself.
6. All names including the school and participants will be kept secret and the location will be "Kartal Campus" for observation.

We can talk together and you can ask anything and request anything regarding access to classroom.

I will follow up with you in a couple days, and I do hope we can meet and see if this may be a possibility.

Sincerely,

Şefika Girgin

Master Student

Yıldız Technical University

Graduate School of Natural and Applied Sciences

M.A. Programme in Elementary Science Education

APPENDIX-C

INFORMED CONSENT FORM FOR TEACHER

Yüksek Lisans Tez Araştırması- İzin Formu (Öğretmen için)

Bu form yüksek lisans tez araştırma çalışmasına katılmak isteyip istemediğinize dair kararınızı etkileyebilecek bilgiler sunmaktatır. Ayrıca, bu form çalışmaya dahil olmaya karar verirseniz onayınızı kaydetmek için de kullanılacaktır.

Kabul ederseniz, bir araştırma çalışmasına katılmanız istenecektir. Şefika Girgin tarafından yürütülen bu çalışma, doğal bir ortam olarak sınıflarda STEM'in nasıl uygulandığını ve öğrencilerin bu sürece nasıl katıldığını gözlemlemek ve yorumlamak üzere yapılacaktır. Araştırma amacı ve soruları STEM dersinin kültürüne odaklanmaktadır.

Bu araştırma için seçilmenizin nedeni çalışmanın örneklemi olan 4. sınıf öğrencilerine ders vermeniz, erken STEM program kitaplarının hazırlık sürecine katılmanız ve erken STEM programına etkili katılım göstermenizdir.

Prof. Dr. Bayram Coştu danışmanlığında Şefika Girgin (sefika.girgin91@gmail.com) tarafından yürütülen ve araştırma metodolojisi kapsamında Bahçeşehir Üniversitesi BAUSTEM merkezi direktörü Doç. Dr. Mehmet Sencer Çorlu ve yardımcı direktör Dr. Zerrin Doğança Küçük tarafından rehberlik edilen yüksek lisans tez çalışması (Erken STEM Eğitiminde Pedagojik Etkileşimler: Etnografik Örnek Olay (Vaka) Çalışması) için erken STEM derslerimin gözlenmesini kabul ediyorum.

Araştırma sürecinde yapılacaklar ve bu çalışmadan anladıklarım şunlardır:

- Sınıfım haftada bir kez erken STEM derslerinde toplam 8 hafta gözlemlenecektir.
- Gözlem sırasında araştırmacı öğrencilerim ve benimle etkileşimde bulunmayacaktr.
- Katılımım gönüllüdür ve araştırmanın amacı, araştırmacıların doğal ortam olarak sınıflarda STEM uygulamalarının nasıl uygulandığının ve öğrencilerin bu sürece nasıl katıldığının gözlemlenmesi ve yorumlanmasıdır.
- Araştırma amacı ve soruları ile ilgili olmayan davranışlarım veya herhangi bir bilgi araştırmada belgelenmeyecektir.
- Benimle ilgili tüm bilgilerin araştırma kayıtlarından kaldırılmasını isteyebilirim.
- Veriler araştırmacı tarafından saklanacaktır.
- Bu çalışmada gözlemlenmeyi kabul edersem, araştırmacıya sınıf sırasında dersimi not defterine kaydetmesine izin veriyorum. Bu notlar, performansım ile ilgili değil, stratejiler ve dersteki süreç üzerine olacaktır.
- Kişisel bilgilerim gizli tutulacak ve kimseyle paylaşılmayacaktır.
- Araştırmacı araştırma süreci veya amacı ile ilgili her türlü sorunuzu cevaplayacaktır.

Bu form üzerindeki imzamla, sınıftaki araştırmanın bir parçası olmayı ve kayıtlar için bu onay formunun imzalı bir kopyasını alacağımı kabul ediyorum.

İmza

Lütfen, yukarıdaki bilgileri okuduğunuzdan, sorularınıza karşı cevaplar aldığınızdan emin olun. Kayıtlarınız için onay formunun bir kopyası size verilecektir. Bu belgeyi imzalayarak, 8 hafta boyunca erken STEM derslerinde araştırmacı tarafından gözlemlenmeyi kabul etmiş sayılmaktasınız.

İsim, Soyisim : Bükrt BAYRAM

Öğretmenin imzası:

Notlar

1. Lütfen iki kopyayı da imzalayınız.

2. Kopyalardan birini kayıtlarınız için saklayınız.

3. Diğer kopyayı araştırmacıya teslim ediniz.

APPENDIX-D

INTERVIEW PROTOCOL FOR EARLY STEM PROGRAM WITH STUDENTS

Giriş-Bilgilendirme

Sevgili …… (öğrencinin ismi)

Bu sene başından itibaren uyguladığınız erken STEM dersleri hakkındaki görüşlerinizi ve düşüncelerinizi belirlemeye yönelik bir araştırma yapıyorum. Bu araştırma için de gönüllü katılımınla birlikte seninle bir görüşme yapmak istiyorum. Bu görüşmeler sayesinde uyguladığınız programın/etkinliklerin daha iyi ve etkili olmasında yardımcı olacaksın.

- ✓ Bu görüşme süresince söyleyeceklerinin tümü gizli tutulacak ve başka hiçbir yerde kullanılmayacak ve kimseyle de paylaşılmayacaktır.
- ✓ Araştırmanın raporunda ismin veya kimliğinle ilgi hiçbir bilgi yer almayacaktır.
- ✓ Görüşmemizin yaklaşık olarak 15-20 dakika süreceğini tahmin ediyorum.
- ✓ Soruların doğru veya yanlış cevabı yok. Senin için doğru olan neyse onu söylemeni istiyorum.
- ✓ Sence de eğer bir sakıncası yoksa görüşmeyi ses kayıt cihazıyla kaydetmek istiyorum.
- ✓ Başlamadan önce belirtmek istediğin bir şey var mı? Bu görüşme ile ilgili sormak istediğin sorular varsa sorabilirsin.

I. Öğrencilerin Demografik Bilgileri

Adın Soyadın:
Kaç yaşındasın?
Annenin ve babanın mesleği nedir?
(Şu anda çalışıyor mu? Veya Daha önceden çalışmış mı? Mühendis ise hangisi?)
Daha önce sınıfında bu tür etkinlikler (STEM etknlikleri, projeler) yaptın mı?
Erken STEM derslerinin hepsine katıldın mı?

II. Erken STEM Programının Temaları ile İlgili Hatırlatma Soruları

- Şu ana kadar erken STEM derslerinde hangi temaları gördünüz?
- Bu temalarda hangi konuları işlediniz? Kısaca bahseder misin?
- Bir ürünü ortaya çıkarırken 8 haftalık süreç boyunca neler yaptınz?
  (Beklenen cevaplar: Araştırma yapma, taslak çizimi, ürün oluşturma ve test etme gibi…)
- Bu temalarda hangi ürünleri ortaya çıkardınız?
  (Yeşil Dünyamız, Makineler Dünyası ve Bilişim Dünyası)

III. Görüşme Soruları

1. Erken STEM dersindeki etkinlikler hakkında ne düşünüyorsun?
Yeşil Dünyamız, Makineler Dünyası ve Bilişim Dünyası temalarında yaptığın etkinlikleri düşünerek cevap verebilirsin.

2. Uyguladığın etkinlikler ve bu etkinliklerdeki konular ilgini çekti mi?
Evet ise hangi yönleri?
Hayır ise neden?

3. Şu ana kadar grup içerisinde aldığın sorumluluklar/görevler neler? Sen bu görevlerden hangisini yapmaktan mutlusun? Başka hangi görevleri almak isterdin?

4. Bilgi edinme sürecinde araştırmalarını nasıl yaptın? Hangi kaynakları kullandın?

5. Etkinliklerin gerçekleştirilmesinde kullandığınız malzemeler sence uygun mu? Daha önce kullandın mı? Kullanırken zorlandın mı?
Evet ise hangi yönden?
Hayır ise neden?

6. Etkinlikleri gerçekleştirirken herhangi bir sorunla karşılaştın mı?
Yaptığınız protatiplerin çalışmadığı oluyor mu? Bu durumda ne yapıyorsunuz?

7. Uyguladığınız erken STEM etkinliklerinde şu ana kadar ürünleri oluştururken neler öğrendin?
"Yeşil Dünyamız" temasında baraj oluştururken, "Makineler Dünyası" temasında oluşturduğun mekanizmayı yaparken ve "Bilişim Dünyası" temasında Mars'ta geçen bir günü planlarken hangi konularda araştırmalar yaptın? Ne tür bilgiler edindin?

8. Erken STEM derslerinde uyguladığın etkinliklerin sana ne gibi yararları oldu? Sana neler kazandırdı (ne tür katkıları oldu)?

Çevrende ve aile yaşantında neleri fark etmeni sağladı?

Bu etkinliklerle birlikte öğrendiğin bilgileri başka nerelerde kullanabilirsin?

9. Erken STEM derslerinde en çok keyif aldığın bölümler nelerdir? Neden?

10. Erken STEM derslerinde en çok zorlandığın bölümler nelerdir? Neden?

11. Ürününüzü sunarken kendinizi nasıl hissediyorsunuz? Sunum sırasında nelere dikkat ediyorsunuz?

Sunumda görev aldın mı? Kendini en rahat hissettiğin sunum hangisiydi?

12. Etkinlikleri daha iyi hale getirmek için önerilerin nelerdir?

13. Şu ana kadar uyguladığın üç temada da *(Yeşil Dünyamız, Makineler Dünyası, Bilişim Dünyası)* bir problemi (BTHP_Bilgi Temelli Hayat Problemi) çözmeye yönelik araştırmalar yaptın ve çözüm yolları aradın. Peki, edindiğin bilgiler yardımıyla çevrende var olan ve çözmek istediğin bir problem önerebilir misin?

Ne tür bir BTHP oluşturabilirsin?

Neden önemli bir problem olarak gördün?

Bu problemi çözmek için neler yapabilirsin?Hangi aşamaları gözden geçirirsin?

Çözüm önerilerin nelerdir?

APPENDIX-E

INTERVIEW PROTOCOL FOR EARLY STEM PROGRAM WITH STUDENTS (ENGLISH VERSION)

Preface

Dear ..... (student's name)

I am doing a research to determine your thoughts about early STEM lessons you have been implementing since the beginning of this year. I would also like to have an interview with you with your voluntary participation for this research. These interviews will help you make your program / activities better and more effective.

- ✓ All interviewees will be kept confidential during this interview and will not be used anywhere else and will not be shared with anyone.
- ✓ The researcher's report will not include any information of your interest or identity.
- ✓ I estimate that our interview will take approximately 15-20 minutes.
- ✓ There is no right or wrong answers to the questions. I just want you to tell that what is right for you.
- ✓ In case you do not mind, I would like to record the interview with the voice recorder.
- ✓ Is there anything you want to mention before you begin? If you have any questions about this interview, you can ask.

I. Demographic Information of Students

Name, surname:
How old are you?
What is the profession of your mother and father?
(Do you work now or have you worked previously?)
Have you ever done such activities (STEM activities, projects) in your class before?
Did you join all of the early STEM courses?

II. Questions for Reminding Themes of Early STEM Program

- What have you done in early STEM lessons so far?
- What topics have you worked on these themes? Are you talking briefly?
- What did you do during the 8-week period when you were uncovering a product? *(Expected answers: research, drafting, product building and testing ...)*
- What products did you reveal in these themes? *(My Green World, My World of Machines and My Computational World)*

III. Interview Questions

1. What do you think about the activities in the early STEM lessons?

You can respond by thinking about the activities you have done on My Green World, My World of Machines and My Computational World themes.

2. Did you apply activities and topics in these activities?

If yes, which aspects?

If no, why not?

3. What are the responsibilities / tasks in the group so far? Are you happy to do these tasks? What other tasks would you like to take?

4. How did you do your research in the process of fact finding phase? What resources did you use?

5. Are the materials you use in the implementation of the activities appropriate? Have you used them before? Were you forced of using them?

If yes, which way?

If no, why not?

6. Have you encountered any problems while performing the activities?

Do you have prototypes that do not work? What are you doing in this situation?

7. What did you learn when you created products so far during your early STEM lessons?

While you were building a dam in the theme of "My Green World", when you were doing the mechanism you created in the "My World of Machines" and planning a day in Mars in the form of "My Computational World", what did you research? What kind of information did you get?

8. What are the benefits of activities you perform in early STEM lessons?

What made you win (what kind of contributions)?

What made you realize in the environment and in your family life?

Where else can you use the information you learned with these events?

9. What are the parts you enjoyed most in early STEM lessons? Why?

10. What are the most difficult sections of early STEM lessons for you? Why?

11. How did you feel when you present your product? What were you paying attention to during the presentation?

Did you take part in the presentation? Which presentation did you feel most comfortable with?

12. What are your suggestions to improve the activities?

13. You have done researches and solutions for solving a problem (APKS_Authentic Problem of Knowledge Society) in the three themes you have applied so far (*My Green World, My World of Machines and My Computational World*). Well, with the help of the information you have, can you suggest a problem that exists in your environment and that you want to solve?

What kind of APKS can you create?
Why do you see it as an important problem?
What steps can you take to solve this problem?
What are the solution suggestions?

APPENDIX-F

INTERVIEW PROTOCOL FOR EARLY STEM PROGRAM WITH TEACHER

Bu sene başından itibaren öğrencilerinize uygulamış olduğunuz erken STEM derslerinin öğrencilerin otantik öğrenme becerileri noktasında bir araştırma yapıyorum ve bu araştırma kapsamında gönüllü katılımınızla birlikte sizin de görüşlerinizi ve düşüncelerinizi belirlemek amacıyla bir görüşme yapmak istiyorum. Bu görüşmeler sayesinde uyguladığınız programın/etkinliklerin daha iyi ve etkili olmasında yardımcı olacaksınız.

- ✓ Bu görüşme süresince söyleyeceklerinizin tümü gizli tutulacak ve başka hiçbir yerde kullanılmayacak ve kimseyle de paylaşılmayacaktır.
- ✓ Araştırmanın raporunda isminiz veya kimliğinizle ilgi hiçbir bilgi yer almayacaktır.
- ✓ Görüşmemizin yaklaşık olarak 20-25 dakika süreceğini tahmin ediyorum.
- ✓ Soruların doğru veya yanlış cevabı yok. Sizin için doğru olan neyse onu söylemenizi istiyorum.
- ✓ Sizce de eğer bir sakıncası yoksa görüşmeyi ses kayıt cihazıyla kaydetmek istiyorum.
- ✓ Başlamadan önce belirtmek istediğiniz bir şey var mı? Bu görüşme ile ilgili sormak istediğiniz sorular varsa sorabilirsiniz.

Görüşme Soruları:

Erken STEM derslerinin uygulanması ile ilgili sorular:

1. Erken STEM eğitimi hakkındaki düşünceleriniz nelerdir?
2. Erken STEM programından önce öğrencileriniz ile bu tür projeler yaptınız mı?
3. Erken STEM programını uygulamadan önce katılmış olduğunuz eğitim, sınıf içi uygulamalarınızı nasıl etkiledi?
   Ne tür yararları oldu?
4. Erken STEM dersindeki sınıf içi rolünüzü ve sorumluluklarınızı nasıl tanımlarsınız? *Diğer derslerdeki rolünüz ile aynı mı?*
   Örnek verebilir misiniz?

5. Erken STEM dersleri diğer dersleriniz üzerinde ne tür etkiler oluşturdu? Olumlu veya olumsuz?
6. Erken STEM derslerinde öğrencilerinizle en verimli geçirdiğiniz süreç hangisiydi? Neden?
7. Erken STEM derslerinde öğrencilerinizle en çok zorlandığınız süreç hangisiydi? Neden?

Erken STEM Program süreci hakkında sorular:

1. Temaların ilk haftasında belirtilen BTHP için öğrencilerin yaklaşımı nasıl oldu?
   BTHP'yi öğrencilere açıklarken nasıl bir süreç takip ettiniz?
   Sonraki temalarda bu süreç nasıl devam etti?
   Ayrıca grupların oluşturulması ve sorumlulukların paylaşımı noktasında nasıl bir yol izlediniz?
2. Bilgi edinme sürecinde öğrenciler araştırmalarını nasıl yaptılar?
   Sınıf ortamı araştırma yapmak için uygun muydu?
   Bu konuda yaşanan problemleri nasıl çözdünüz/çözerdiniz?
3. Fikir geliştirme sürecinde grup içerisindeki iletişim, fikirlerin oluşturulup seçilmesi konularında öğrenciler açısından herhangi bir sorunla karşılaştınız mı?
   Evet ise bu sorunu nasıl çözdünüz?
4. Ürün geliştirme sürecinde öğrencilerin grup içindeki etkileşimleri hakkında ne düşünüyorsunuz? Birinci temadan itibaren bu süreç nasıl gelişti?
   Birbirleri ile olan iletişimleri, sorumluluk paylaşımı, öğretmen ile iletişimleri…
   Özellikle son temada ürün geliştirme aşamasında zaman sıkıntısı sorununu nasıl çözdünüz? Öğrenciler bu süreçte nasıl bir yol izlediler?
5. Bilgilerin derinleştirilmesi için ne tür bir yol izlediniz? Bu süreçte öğrencilerin bilgilerini nasıl değerlendirdiniz?
6. Ürün portfolyolarının hazırlanması sürecinde öğrencilere nasıl rehberlik ettiniz?
   Öğrencilerin bu konudaki hazırbulunuşluklarını da göz önüne alarak cevaplayabilirsiniz.
7. Sunum haftalarında öğrenciler nasıl bir hazırlık sürecinden geçti?
   Grup içi görev paylaşımı, sunum sürecini nasıl değerlendirirsiniz?

Erken STEM derslerinin öğrenciler üzerindeki yansımalarına yönelik sorular:

1. Erken STEM derslerinin öğrencilerin başarısı ve becerileri üzerinde ne tür etkileri olduğunu düşünüyorsunuz?
   Bilginin transferi ve öğrenme üzerinde nasıl bir role sahip olduğunu düşünüyorsunuz?
2. Erken STEM derslerinin öğrencilerin mesleki kariyerleri için bir farkındalık oluşturduğunu düşünüyor musunuz?
   Evet ise nasıl?Hayır ise neden?
3. Birinci temadan son temaya kadar olan süreçte öğrencilerinizin nasıl bir ilerleme kaydettiğini düşünüyorsunuz?
4. Erken STEM eğitiminin öğrencilerin becerilerini, farkındalıklarını ve başarılarını geliştirmesi noktasında ne tür öneriler ve eklemeler yapabilirsiniz?

APPENDIX-G

INTERVIEW PROTOCOL FOR EARLY STEM PROGRAM WITH TEACHER (ENGLISH VERSION)

I am doing research on the authentic learning experiences of students in early STEM lessons that you have already applied to your students since the beginning of this year, and in this research I would like to have an interview with you to determine your views and considerations with your voluntary participation. This interview will help in making the program / events better and more effective.

- ✓ All interviewees will be kept confidential during this interview and will not be used anywhere else and will not be shared with anyone.
- ✓ The researcher's report will not include any information of your interest or identity.
- ✓ I estimate that our interview will take approximately 20-25 minutes.
- ✓ There is no right or wrong answers to the questions. I just want you to tell that what is right for you.
- ✓ In case you do not mind, I would like to record the interview with the voice recorder.
- ✓ Is there anything you want to mention before you begin? If you have any questions about this interview, you can ask.

Interview Questions:

Questions regarding the implementation of early STEM lessons:

1. What are your thoughts on early STEM education?
2. Did you do such projects with your students before the early STEM program?
3. How did the training you participated before implementing the early STEM program affect your classroom practices?

   What benefits did they have?
4. How do you define your classroom role and responsibilities in the early STEM lesson? Is it the same as your role in other lessons?

Could you give an example?

5. What kind of effects did the early STEM lessons have on your other lessons? Positive or negative?
6. Which process did you spend most effectively with your students in early STEM lessons? Why?
7. Which process was the most difficult for your students during the early STEM lessons? Why?

Question on Early STEM Program process:

1. What was the approach of the students for the BTHP mentioned in the first week of the themes?

   What kind of process did you follow when explaining APKS to students?

   How has this process continued in the following themes?

   Also, how did you come about the creation of groups and the sharing of responsibilities?

2. How do students conduct their research in the process of obtaining information?

   Was the classroom environment suitable for research?

   How did you solve the problems in this regard?

3. Have you encountered any problems in terms of students in the communication process within the group during the idea development process, and the creation and selection of ideas?

   If so, how did you solve this problem?

4. What do you think about the student interactions within the product development process? How has this process developed from the first theme?

   Communication with each other, sharing responsibility, communication with the teacher...

   How do you solve the problem of time constraint, especially in the product development phase in the last episode? How did the students follow this path?

5. What kind of path did you follow to deepen the students' knowledge? How did you evaluate the knowledge of students in this process?
6. How did you guide the students in the process of preparing their product portfolios? You can also answer by considering the students' readiness on this issue.
7. What kind of preparation process did the students go through during the presentation week?

   How do you rate the presentation and group task sharing process?

Questions about the reflection of early STEM lessons on students:

1. What do you think about the effects of early STEM lessons on students' success and ability?

   What role do you think it has on the transfer of knowledge and learning?

2. Do you think that early STEM lessons create awareness on the professional career of students?

   If yes, how? If no, why?

3. How do you think your students have progressed from the first to the last theme?

4. What kinds of suggestions and attachments can you make at the point that early STEM education improves the skills, awareness and success of students?

APPENDIX-H

OBSERVATION PROTOCOL FOR EARLY STEM PROGRAM

Types of Authenticity	*Key Definitions*	*Phases of STEM Learning Cycline*	*Assignments based on weeks*
Context Authenticity	*Context Authenticity* situates the work in reality and allows students to gain genuine understanding of a phenomenon in a scientific way. It helps "bring real world experience to the classroom" (Strobel et al., 2013, p. 147).	1st Week *Engagement / APKS*	Presenting the real-world problem statement (APKS) Questioning Creation of groups Taking responsibilities
Task Authenticity	*Task Authenticity* occurs when students are engaged in the type of work actually done within a profession. Authentic tasks "challenge students in decision-making in practical contexts" (Strobel, et al., p. 147).	2nd Week *Exploration / Fact finding*	Recalling the real-world problem (APKS) Revealing students' pre-knowledge about subject matter Searching information to solve the problem Ways of getting information; sources of information Using acquired knowledge
		3rd Week *Exploration / Ideation*	The ways of creation idea Expression of the ideas Selection of the best ideas Using acquired knowledge
Impact Authenticity	*Impact Authenticity* occurs when student's work impacts the real world in some way. The impact may take the form of "participation as effective citizens" and promote "minorities' experiences in the role of engineers and scientists" (Strobel et al., 2013, p. 147).	4th Week *Explanation / Product development*	Recalling the real-world problem (APKS) Sketching the ideas (drafting) Designing of the product Improvement of the developed product
		5th Week *Elaboration / Product development*	Development of the product Deepening the learning
		6th Week *Explanation-Elaboration / Refinement*	Development of the product Deeping the learning Testing the developed product
Personal/Value Authenticity	*Personal Authenticity* involves students' personal culture and professional goals. It allows the learning activity to do more than "simply [prove] their competence" (Strobel et al., 2013, p. 147).	7th Week *Evaluation / Dissemination*	Evaluation of the learning and product Preparation for the expo Preparation of the portfolios Trial presentation of the products to the class
		8th Week *Expo Week*	Group motivation Presentation of the products to visitors/ parents Reviewing the process

CURRICULUM VITAE

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Foreign Languages : English & Korean

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EDUCATION

Degree	**Department**	**University**	**Date of Graduation**
Master	Science and Mathematics Education	Yıldız Technical University	2018
Undergraduate	Science Education	Boğaziçi University	2015
High School	Science	Rami Atatürk (Anatolian) High School	2009

WORK EXPERIENCE

Year	**Corporation/Institute**	**Enrollment**
2017-2018	Prof. Dr. Necmettin Erbakan Science and Culture Center	Science Teacher

PUBLISHMENTS

Conference Papers

1. Girgin, Ş. and Coştu, B. (2017). "Investigating Students' Authentic Learning Experiences in Early STEM Lessons", International Congress on Afro-Eurasian Research III (ICAR), 19-21 October 2018, İstanbul, Turkey. *(Created within the scope of master thesis)*
2. Doğança Küçük, Z., Aşık, G. and Girgin, Ş. (2017). "Teachers' Views on the Implementation of an Early STEM Education Program", 12th Conference on the European Science Education Research Association (ESERA), 21-26 August 2018, Dublin, Ireland.
3. Doğança Küçük, Z., Aşık, G., Girgin, Ş. and Çorlu, M.S. (2017). "Teachers' Views about Implementing an Engineering-Focused Theme within an Early STEM Program", International Conference on Education in Mathematics, Science & Technology (ICEMST),1-3 May 2018, Kuşadası, Turkey.
4. Bektaş, R., Girgin, Ş. and Aksöz, B. (2016). "Fen Bilgisi Öğretmenleriyle Odak Grup Görüşmesi: FeTeMM İhtiyaç Analizi", 12th National Science and Mathematics Education Congress (Ufbmek), 21-25 September 2016, Trabzon, Turkey.
5. Coştu, B., Bektaş, R. and Girgin, Ş. (2016). "Revealing Students' Cognitive Structure of Optics through Word Association Test", 3rd International Eurasian Educational Research Congress (International EJER Congress), 1-3 June, Muğla, Turkey.

Books

1. Girgin, Ş. (2017). erkenSTEM Etkinlik Kitabı-1, Ugur Foundation Education and Publishing, İstanbul.
2. Girgin, Ş. (2017). İlkokullar için STEM Etkinlik Kitabı: Bir İnşaat Aranıyor, Pusula Publishing, İstanbul.
3. Girgin, Ş. (2017). 3.Sınıf Fen Bilimleri Akıllı Defter ve Ev Ödevi, Isabet Publishing, İstanbul.
4. Girgin, Ş. (2017). 8.Sınıf Fen Bilimleri Kitabı, Isabet Publishing, İstanbul (in publication process).

Projects

1. Martian Engineer Girls Project (October-November, 2017), *(Within the scope of the American Embassy Business Association)*, Instructor responsible for STEM events.

   - Three days STEM Education was given in İzmir Space Camp
   - Two days STEM Education was given in BİLSEM (Samsun)
   - Two days STEM Education was given in TAKEV Schools (Samsun)

AWARDS

1. Certificate of award the International Congress on Afro-Eurasian Research III (İstanbul-2017) for the paper entitled "Investigating Students' Authentic Learning Experiences in Early STEM Lessons" on behalf of the award juries.
2. Honor Certificate, Boğaziçi University, 2015.