REPUBLIC OF TURKEY
YILDIZ TECHNICAL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

INTERDISCIPLINARY STEM EDUCATION: EXPLORING TECHNOLOGY AND ENGINEERING INTEGRATION IN MATHEMATICS AND SCIENCE CLASSES

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A thesis submitted by Başak HELVACI ÖZACAR in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** is approved by the committee on 20.06.2018 in Department of Mathematics and Science Education, Science Education Program.

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June, 2018

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LIST OF SYMBOLS

κ	Cohen's kappa coefficient
i	Number of raters
k	Number of categories
P_o	Relative observed agreement among raters
P_e	Hypothetical probability of chance agreement
N	Number of items
n_{ki}	Number of times rater i predicted category k

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variances
APoKS	Authentic Problems of Knowledge Society
BAUSTEM	Bahçeşehir University STEM Center
CT	Computational Thinking
IB	International Baccalaureate
ICT	Information and Communication Technologies
ITF	Integrated Teaching Framework
ITP	Integrated Teaching Project
LMS	Learning Management System
MM	Mathematical Modeling
MoNE	The Ministry of National Education
NGSS	Next Generation Science Standards
NRC	National Research Council
OECD	Organization for Economic Co-operation and Development
PBL	Problem-Based Learning
PD	Professional Development
PDoNE	Provincial Directorate of National Education
PI	Principal Investigator
SI	Scientific Inquiry
STEM	Science Technology Engineering Mathematics
TALIS	The Teaching and Learning International Survey
TUBITAK	The Scientific and Technological Research Council of Turkey
TUSIAD	Turkish Industry and Business Association
YEGITEK	The Ministry of Education's General Directorate of Innovation and Education Technologies

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ABSTRACT

INTERDISCIPLINARY STEM EDUCATION: EXPLORING TECHNOLOGY AND ENGINEERING INTEGRATION IN MATHEMATICS AND SCIENCE CLASSES

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STEM education is one of the trend topics in education in many countries, especially in Turkey. One of the biggest concern in STEM Education is the efficient and meaningful use of technology and engineering. Qualified and tech-savvy teachers are needed for the area as a result of the pedagogy of STEM Education and the interconnectedness of these disciplines. New research and professional development programs are required to be conducted when such post-modern paradigms raise because teachers are being asked to become proficient at new skills and responsibilities and implement these into their practices.

This study investigates how STEM teachers implement and integrate technology and engineering, which tools do they use more frequently as a part of their science and mathematics lessons in 5th and 6th-grade topics. The ulterior motive of the study is to explore the effect of integrating technology and engineering in overall quality of STEM lesson plans.

The data obtained from 32 science and mathematics teachers who participated in *TÜSİAD STEM Project*: a teacher professional development program. The teachers attended to four face-to-face STEM workshops, each received one STEM kit with a guide including six STEM lesson plans. During this professional development program, at least one lesson plan was implemented by participant teachers and they gathered together to reflect on their classroom experiences. At the end of the professional development program, teachers created their own authentic lesson plans. These lesson plans were investigated in terms of interdisciplinarity - integrating technology and engineering into science and mathematics classes.

Overall, findings demonstrated that the science and mathematics teachers in the professional development program integrate technology and engineering in six different categories. Although, there is no significant difference reported of integrating technology on the quality of STEM lesson plans, engineering integration showed a significant difference on the quality of STEM lesson plans.

Keywords: STEM education, integrated teaching, teacher education, professional development

ÖZET

STEM EĞİTİMİNDE DİSİPLİNLER ARASILIK: MATEMATİK VE FEN BİLİMLERİ DERSLERİNDE TEKNOLOJİ VE MÜHENDİSLİK ENTEGRASYONU

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STEM eğitimi özellikle Türkiye olmak üzere birçok ülkede popülerdir. STEM eğitimindeki en büyük kaygılardan biri teknoloji ve mühendisliğin etkili ve anlamlı şekilde kullanımıdır. Nitelikli ve teknolojiyi yakından takip eden öğretmenlere olan ihtiyaç; STEM eğitiminin pedagojisi ve STEM alanlarının birbirleri ile bağlantıları sonucu ortaya çıkmıştır. Hızla değişen dünya ve post modern paradigmalar; öğretmenlerin yeni beceriler kazanmalarını gerektirir ve onlara yeni sorumluluklar yüklerken; yeni araştırmaların yapılması ve öğretmen mesleki gelişim programlarının düzenlenesi bir gerekliliktir.

Bu çalışmanın STEM öğretmenlerinin 5. ve 6. sınıf fen bilimleri ve matematik derslerinde, teknoloji ve mühendisliği nasıl ve hangi araçlarla bütünleştirdiği ve uyguladığını araştırmaktadır. Çalışmanın bir diğer hedefi ise öğretmenlerin, teknoloji ve mühendislik disiplinlerini kendi disiplinleri ile bütünleştirmelerinin STEM ders planlarının genelindeki etkisini keşfetmektir.

Araştırmada bir öğretmen mesleki gelişim programı olan TÜSİAD STEM Projesi'ne katılan 32 fen bilimleri ve matematik öğretmeninin STEM ders planları veri olarak kullanılmıştır. Programa katılan öğretmenler dört yüz yüze STEM çalıştayına katılmış, içinde 6 ders planının olduğu bir rehber ve bir STEM kiti almıştır. Bu mesleki gelişim programı süresince öğretmenler en az bir ders planını sınıflarında uygulamışlar ve deneyimlerini paylaşmak üzere bir araya gelmişlerdir. Programın sonunda öğretmenler kendi özgün ders planlarını hazırlamışlardır. Hazırlanan STEM ders planları disiplinler arasılık ilkesi — teknoloji ve mühendislik disiplinlerinin matematik ve fen bilimleri disiplinleriyle bütünleştirilmesi çerçevesinde incelenmiştir.

Sonuç olarak, bulgular öğretmen mesleki gelişim programına katılan fen bilimleri ve matematik öğretmenlerinin teknoloji ve mühendislik disiplinlerini altı farklı kategoride bütünleştirdiğini göstermektedir. Teknoloji disiplininin bütünleştirilmesi STEM ders planlarının genelinde anlamlı bir değişikliğe sebep olmazken, mühendislik disiplininin bütünleştirilmesinin istatistiki olarak anlamlı bir değişikliğe sebep olduğu saptanmıştır.

Anahtar Kelimeler: STEM eğitimi, bütünleşik öğretmenlik, öğretmen eğitimi, mesleki gelişim

CHAPTER 1

INTRODUCTION

1.1 Literature Review

In the 21^{st} century, the everchanging technologies and industrial revolutions of this postmodern era brought necessity for every individual to acquire some specific skills around 21^{st} century themes and core subjects. These skills are learning and innovation skills, information, media and communication skills, life and career skills [1]. The need for these skills led to the emergence of new strategies, notions, models, and frameworks in education. The unity of the disciplines: science, technology, engineering and mathematics (STEM) is one of the newly emerged frameworks in education.

Although STEM is a contemporary term to bring interrelated disciplines under the same roof, the idea of focusing on the intersections of different disciplines is rather old [2]. The earliest article was published in 1905 on the topic of integrated science and mathematics [3]. The concept of integration was expressed differently over the last hundred years, it was called the integrated curriculum during the 1920s; the core curriculum during the 1930s; the problem-centered core curriculum during the 1940s and 1950s; the interdisciplinary curriculum during the 1980s and 1990s [4, 5]. During the early 1980s, interdisciplinarity was introduced as a form of co-operation between various disciplines, which contribute to the achievement of a common end and which, through their association, further the emergence and advancement of new knowledge [6]. The integration of science and mathematics, in other words, interdisciplinarity approach towards these disciplines is a recurring theme to achieve curricular goals [7].

In traditional science and mathematics classrooms, subject matter is often taught in an isolated way; mathematics teachers focus on mathematics content, and science teachers focus on science content. Yet, interdisciplinary curriculum includes problems and activities that cross lines of different disciplines and more closely resemble science, mathematics, and engineering applications and real-world problems [7]. Connection to the real-world and non-isolated mathematics and science classes were argued by Dewey under the term "learning by doing" and he indicated the weakness of almost all schools as the separation of school studies from the actual life of children and the conditions and opportunities of the environment. [8]. Dewey's report about Turkish education influenced teacher training in the 1930s and the elementary curricula in 1948 in Turkey [9]. Dewey's pragmatic educational approach seeks a practical way to connect school studies to real-world without implementing major changes in education [10,11]. As a result, elementary curricula of 1948 were created by considering the integration of all disciplines under the headings of life sciences, natural sciences and family knowledge [12].

While Dewey emphasized the link between the disciplines and practical applications, Piaget pointed out collaborative and creative assets of interdisciplinarity [1]. Following Dewey's and Piaget's works, the term interdisciplinarity was studied by many researchers in the 20th century [14-18]. These ideas, definitions, frameworks and models formed a basis for STEM.

During the first decade of 21st century, STEM was used quite commonly to point out the individual disciplines and the interdisciplinarity [19]. There is no general agreement on defining this framework, various interpretations and definitions of STEM education have arisen in the literature [20]. Some researchers refer to STEM education as each individual discipline while others point out the intersection of these disciplines [21]. STEM education has been defined by Çorlu et al. as follows:

> "knowledge, skills, and beliefs which are collaboratively constructed [by students and teachers] at the intersection of more than one STEM subject area" [22].

This definition does not only stress knowledge on subject areas but also skills and beliefs. While Bybee's definition of true STEM education emphasizes mainly the efforts to increase students' understanding of how things work and how they use technology [23]. Some researchers like Sanders add a non-STEM discipline to the equation and defines STEM education as;

> "Teaching and learning between/among any two or more of the STEM subject areas and/or between a STEM subject and a non-STEM subject such as the Arts [20].

There exists an obvious and expected confusion towards STEM education because of the appearance of different definitions in the literature. The confusion has uttered in various articles one of which states that STEM education covers the full spectrum from a mix-and-match or continuum approach, inter- and multi-disciplinary, through to a fully integrated view of STEM education [21, 22].

While STEM education is seen as a relatively new field in educational research, countries and international organizations are concerned with the economic outcomes of STEM education. As employment is the driving force of economic growth, STEM professions are expected to become even more important in the coming years and it is imperative that the supply of STEM skills keep pace with this increasing demand [25-27].

1.1.1 Necessity of STEM Education

The essential purpose of STEM education is to raise the current generation with innovative mindsets [28]. With an effective STEM education program, overlapping concepts and principles can be brought together in a meaningful way, students are encouraged to make new and productive connections across two or more disciplines, which also lead to meaningful learning experiences, improved student learning and transfer as well as interest and engagement. [29-31]. One other expectation of STEM education is to support students to become competent in 21st century skills.

For individuals to be equipped with the most appropriate skills to work in STEM fields, it is very important to assess what skills are most needed. Given the rapidly changing nature of the today's world, the evolution of these skills must be closely monitored, thus European Union (EU) and Organization for Economic Co-operation and Development (OECD) published several reports in the past ten years concerning the growing need for developing the right STEM skills to overcome the challenges the human-kind will face in the near future [25, 26, 32, 33]. These challenges were underpinned by The OECD Education 2003 as the following;

(a) Environmental Challenges,
(b) Economic Challenges and
(c) Social Challenges [34].

To reveal the STEM skills necessary to overcome these challenges, several studies focusing on STEM education and the expected outcomes have been carried out for the last three decades [35]. Many of these researches indicate not only improved problem-solving skills, increased motivation and developed mathematics and science understanding as the outcomes of STEM education [36, 37] but also increased awareness towards the applications of the content knowledge [38, 39]. Burrows and Slater also discuss that STEM education can help the next generation of students to solve real-world problems by applying concepts that cut across disciplines as well as capacities of critical thinking, collaboration, and creativity [40].

All in all, an early interest in STEM topics can be a predictor for later learning and eventual career intentions and also excellence in STEM education can impact business, productivity and competitiveness in many sectors and in the field, such as health, technological innovation, manufacturing, informatics, politics, cultural and social change [41, 42].

1.1.2 Interdisciplinarity in STEM Education

Crossing between the boundaries of the disciplines, interdisciplinarity can contribute to the development of generation with innovative mindsets. A holistic perception of the world can be achieved with interdisciplinarity training [43]. Since the beginning of 20th century, educational researchers have studied the integration of interrelated disciplines, mathematics and science. In defining how to integrate mathematics and science, Berlin and White suggested to collect and use data in problem-based integrated activities that invoke process skills, use instructional strategies that would bridge the gap between students' classroom experiences and real-world experiences outside the classroom [44]. A student-centered approach was also apparent in the study of Sunal and Furner, they remarked on students' experiences, organization, and thought about mathematics and science, as well as meaningful integration [45]. Integration is not only mixing of disciplines but also generating meaningful classroom activities that are relevant, engaging, and aiming at the curricular standards and scopes.

According to Lonning and DeFranco, the reason for the integration of mathematics and sciences is related to the issues of increasing the meaningfulness of both disciplines [46]. In their study in 1997, they presented the following continuum of integration mathematics and science to characterize the nature of relationship between disciplines.

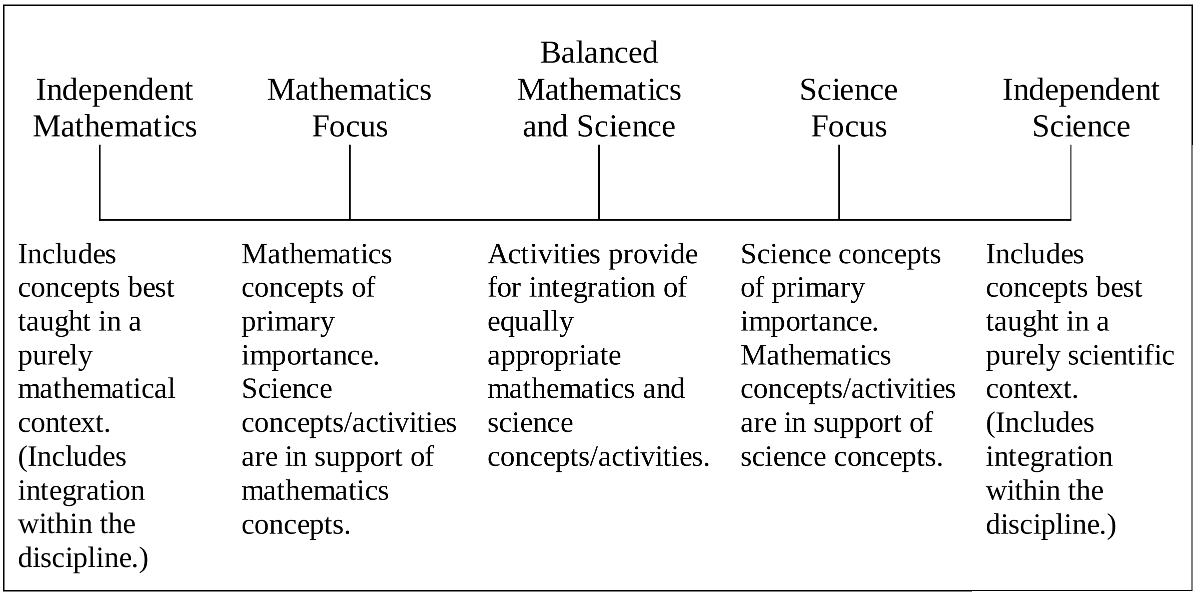

Figure 1.1 Integration of mathematics and science continuum [46]

Although many researchers studied the methodology of integration of science and mathematics, Davison et al. investigated the meaning and types of integration in order to understand the integration found between and among science and mathematics. According to them, there are five types of integration; discipline specific integration, content specific integration, process integration, methodological integration and thematic integration.

Table 1.1 Types of Integration [47]

Types of Integration	
Discipline Specific Integration	an activity that includes two or more different branches of mathematics or science
Content Specific Integration	an activity that involves instruction in each of existing curriculum objective from mathematics and science
Process Integration	integrating curriculum through the use of real-life activities in the classroom
Methodological Integration	a scientific or mathematical methodology that is integrated in the other discipline’s teaching
Thematic Integration	a theme which then becomes the medium with which all the disciplines interact

These types of integration also a predictor of the relationships in between the disciplines. In 2013, Vasquez et al., argued the increasing levels of integration on disciplinary concepts. This study pointed out different forms of integration; disciplinary, multidisciplinary, interdisciplinary and transdisciplinary integration. Interdisciplinary integration involves closely linked concepts and skills which are learned from two or more disciplines with the aim of deepening knowledge and skills [48]. Preparation of interdisciplinary instruction requires the lesson or unit to support learning skills and content of at least two disciplines, to use new knowledge and skills from these discipline of competence as well as to enable the teacher to engage and encourage the students [16]. Given the rigorous nature of interdisciplinarity, Jacobs suggested that planning and teaching interdisciplinary lessons should involve two or more teachers, common planning time, the same students, teachers skilled in professional collaboration, consensus building, and curriculum development [49].

A relatively recent study by Gero in 2017 collected and compiled different hierarchies of interdisciplinarity in the research literature, which are based on the level of integration between different disciplines.

Table 1.2 Different hierarchies of interdisciplinarity [50]

Level of Disciplinarity	
Informed Disciplinarity	emphasis is put on a single discipline; however, other disciplines are used to shed light on specific issues of the discipline discussed
Synthetic Interdisciplinarity	terms and theories of different disciplines are integrated, when the terms or theories can be attributed to a specific discipline
Transdisciplinarity	terms and theories of different disciplines are integrated to such an extent that the terms or theories cannot be attributed to a certain field
Conceptual Interdisciplinarity	disciplinary perspectives are integrated without a compelling disciplinary basis

As well as the varying interpretations in terms of interdisciplinarity, the different interpretations of STEM education in the literature existed and led to the integrated STEM education terminology [51,52]. Integrated STEM education is an effort to combine science, technology, engineering and mathematics based on connections between subjects and real-world problems. However, integrated STEM education may involve more than one class and teacher and does not necessarily include STEM's four disciplines as

Stohlmann et al. and Corlu et al. adverted [24,22]. According to the report of Committee on Science and Technology, integrated STEM education is an approach to teaching that is larger than the STEM disciplines apart [52]. While some researchers still recognize the importance of integrating technology as the "T" in STEM, technology integration appears to be grasped in very different ways, reflecting the range of technology integration from superficial to transformative [51].

Furthermore, the reason behind integrating STEM disciplines was lying on the fact that in a complex, globalized world, citizens are responsible of making use of multidisciplinary knowledge in order to understand and address the multifaceted issues and concerns they face [53]. School curricula, however, usually compartmentalize knowledge into isolated disciplines [54]. From this perspective, intelligent integration is important. The difficulty with integration is intensified lately due to insufficient or lack of the attempts to either replace or offer as an alternative, an integrated STEM curriculum to support teachers [55].

Along with the changing global prospect, the views towards STEM education have been transforming in Turkey. In January 2017 Turkish Ministry of National Education (MoNE) released the draft curriculum of elementary science education. In this draft, there was an additional STEM chapter which was planned to be covered at the end of spring term in grades 3 to 8. This additional chapter was named "Science and Engineering Applications" [56].

The process of developing a new curriculum continued with pilot studies in 5^{th} grade science classes and feedback was gathered from science teachers all around the country [57]. MoNE published the final version of the curriculum in January 2018 just after one year. The collective efforts of both academicians and in-service teachers to create the best curriculum focusing on the 21^{st} century needs, taking into consideration the social and cultural settings can be seen as a revolution in education.

1.1.3 Teacher Professional Development (PD) Programs

The teacher professional development is a lifelong process which starts with the initial preparation as a pre-service teacher and continues until retirement time [58]. Unfortunately, current teacher education is reported as inadequate, and several researchers proposed a change both in the quality and duration of teacher professional developments [28]. In concordance with the findings of the research, both pre-service and in-service teachers' responses suggested the need for STEM teacher education courses and workshops on integration and bridging multiple STEM disciplines through teamwork in real-world problem solving [59].

A substantial body of research also demonstrated that teacher professional development can assist student achievement in STEM disciplines. A longitudinal, quasi-experimental study by Saunders et al. compared two groups of teachers during a three-year period and found that the teachers who received professional development had greater student achievement [60]. These findings have been supported by previous research, which showed that teacher participation in professional development programs is associated with continued growth in state assessment scores across the years and increases in students' academic achievement [61-64].

Moreover, in the literature implications for teacher professional development programs highlighted as follows:

(a) more exposure to concepts, processes, and skills in STEM that is similar, analogous, complementary, or synergistic;

(b) familiarity with instructional strategies and access to resources;

(c) a deeper understanding of content across STEM; and

(d) strategies for collaboration and teamwork to make integrated instruction time more efficient and less difficult to manage [65].

However, there is still need for investigating the prerequisite skills, beliefs, knowledge bases, and experiences necessary for teachers to implement integrated STEM education in their classes [36]. The deductions from these studies can be summed up as more research on developing teacher professional development program content should be done, more opportunities for teachers to participate in long-term professional development should be generated.

1.2 Objective of the Thesis

The objective of this present study is to critically explore the technology and engineering integration in mathematics and science lesson plans in order to identify the contribution to STEM lesson plan quality. With this objective, it is aimed to reveal the effect of integrating several disciplines into one lesson on the different parts of a whole STEM lesson plan. In an attempt to find out the correlation between technology/engineering integration and overall lesson plan quality, the following three research questions have arisen:

Is there a statistical significant main effect of technology and engineering use on the quality of 5^{th} and 6^{th} grade mathematics and science lesson plans?

Is there a statistical significant main effect of the discipline of teachers on the quality of lesson plans?

Is there a statistical significant interaction effect of technology and engineering use and discipline on the quality of lesson plans?

In what ways and to what extent do teachers utilize technology and engineering in their STEM lesson plan?

The answers to these research questions are expected to enable the researcher to make meaningful comparisons in between different studies and their effect sizes.

1.3 Hypothesis

STEM Education encourages students to make new and productive connections across two or more disciplines, which also lead to meaningful learning experiences, improved student learning and transfer as well as interest and engagement [29-31]. While designing interdisciplinary curricula attention must be paid to not only what is being integrated but also to what extend each subject is being integrated [17]. Therefore, the hypothesis of the study is that the quality STEM lesson plans of the teachers who integrated technology and engineering objectives into their mathematics and science classes are expected to show a statistical significant positive effect.

The rationale of this study is to explore an aspect which has not yet investigated by other researchers. As provided in the previous subsections by reviewing the literature, one can deduce that the teacher professional development programs are prevalent but not sufficient across the countries. Although the effects of integrating particular disciplines have been studied and sound outcomes regarding the student achievement have been stated, the effect of integration in the overall quality of teachers' lesson plan has not been studied in the manner that this study covers [60-64, 67]. Investigation of interdisciplinarity: integration of different disciplines such as technology and engineering into mathematics and science classes is a necessity. Therefore, to explore the effects of integrating technology and engineering on the STEM lesson plan quality is believed to be a unique context to study in order to see from the teachers' perspective. By taking into account the effects of integrating different disciplines, more effective teacher professional development programs can be developed.

Last but not least, in words of National Academies to be able to "rise above the gathering storm" and to have "a brighter future", teachers are the key elements on this process. Just as this referred storm which is going to cover the whole globe, the brighter future is also going to be for the nations that act accordingly. Recommendations for raising innovative, creative, collaborative, critical thinker, and tech-savvy generations include calls for increased recruitment of science and mathematics teachers, expanded teacher education, promotion of the STEM pipeline through K–12 education, greater research funding, and adoption of economic policies that would foster innovation in mathematics and science [68].

The following four outcomes are also the main rationale of the teacher professional development program;

(a) Flexible Curriculum: TUSIAD STEM kit, application guide and face-to-face teacher professional development,
(b) Professional Learning Community: TUSIAD STEM portal and online teacher training within this portal,
(c) Knowledge Society: TUSIAD STEM Fair and
(d) Impact analysis report and academic studies [69].

To conclude, the rationale of this present study mainly focuses on the last item of the above outcomes. To investigate the specific outputs – STEM lesson plans of this STEM teacher professional development program in terms of technology and engineering integration is chosen to form a basis for teacher focused STEM research.

CHAPTER 2

FRAMEWORK OF THE STUDY

In this chapter, related studies on STEM education, teacher professional development programs as well as the framework of the present study are presented.

2.1 Related Studies

In the context of this project, some of the necessary equipment necessary for the practice and necessary knowledge to facilitate full integration were supplied. With face-to-face STEM workshops and teacher guide, it was aimed to inspire teachers to create their own authentic STEM lesson plans. The need for teacher professional developments to encourage teachers and support them to connect different disciplines was argued by Ríordáina et al. in 2016 [70]. She and her colleagues pointed out the demand for the knowledge of the 'other' subject and mentioned that the teachers viewed mathematics and science as being very different, distinctive subjects [70].

Another aspect of integration is to emphasize logical and conceptual connections across different STEM disciplines which are also a remedy for the problem asserted by Ríordáina. Thus, not only curricular but also pedagogical coherence across different STEM fields should be maintained [71]. As stated in Next Generation Science Standards (NGSS) in 2015 STEM education should be treated as a whole [72].

Another aspect of planning interdisciplinary lesson plans is the investment of time, thoughts and setting. According to Jacobs, planning and teaching interdisciplinary lessons should involve two or more teachers preferably from different disciplines. Also, common planning time, professional collaboration, consensus building, and curriculum development are required to develop interdisciplinary lesson plans [49]. As Robinson

(1994) pointed out, the following considerations are necessary for the preparation of interdisciplinary instruction;

(a) An understanding of the nature of subject field,
(b) A deeper knowledge of methods of interdisciplinary subject matter correlation,
(c) Strategies for motivating students to use process skills, such as reporting, research, problem solving, mathematical application, data collection, data analysis and drawing conclusions [16].

When teachers' teaching a topic that they are not familiar with is not different from the experience of teaching outside the field. Teacher's subject identities are created through the involvement and recognition of the relevant subculture. For this reason, professional development programs have the potential to distort a teacher's competence, self-efficacy and well-being [73, 74].

Findings in the literature also support the conclusion that high-quality sustained teacher professional development programs have statistically-significant positive effects on teaching practices [75- 79]. Unfortunately, the positive effects are not linear, less effective professional development programs might have no or negative effect [78, 80].

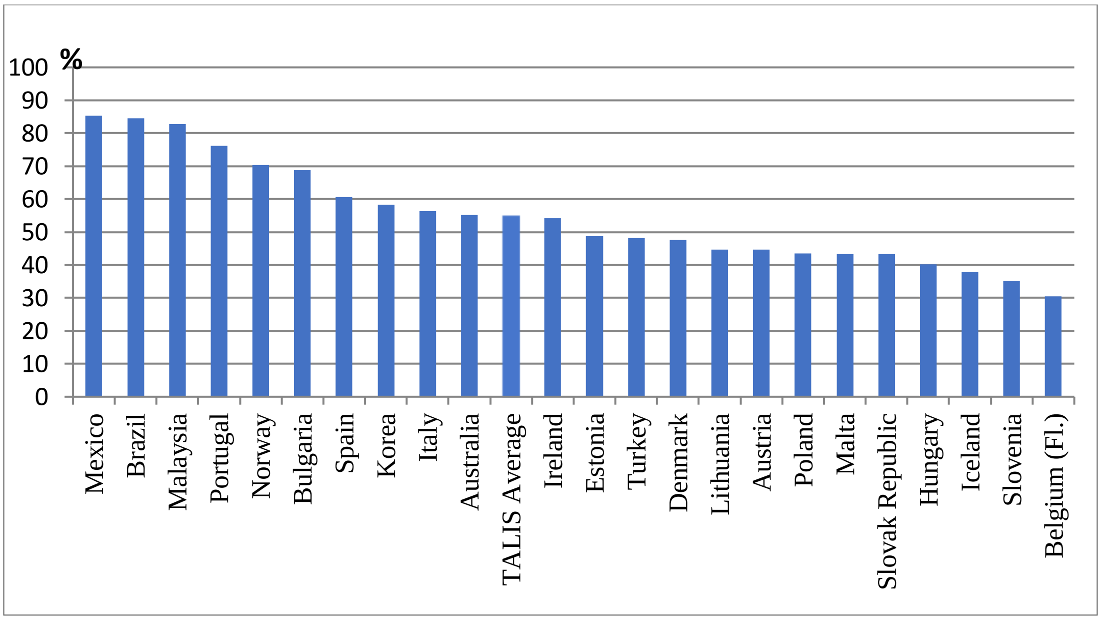

Figure 2.1 Percentage of teachers who wanted more development than they received in the 18 months prior to the TALIS survey (2007-08) [81]

Figure 2.1 represents the percentage of teachers who wanted more development than they received in the last year and a half [81]. Turkish teachers situated just below the average, 48% of the teachers stated that they wanted to participate in teacher development programs more than they did. These dates are between June 2006 and December 2008. There is a decade difference in between this research and the present study. It can be misleading to make any deductions from these percentages for today. Another study by Doğança Küçük et al. on early STEM context reports that although 30.5% of the teachers mentioned about their lack of their STEM knowledge for teaching, only 12.25% of the teachers stated their need for professional development about STEM education [82].

In a recent study by Türk et al., the gap between theory and practice of interdisciplinarity was addressed [83]. The participants of the study, faculty members, in-service teachers and pre-service teachers, stated the need for active and effective professional development programs for in-service teachers as well as undergraduate courses for pre-service teachers for acquisition of integrated teaching knowledge (ITK) [83].

In Turkey's context, teacher professional development programs are mainly conducted by MoNE and PoNE offices for the public school teachers only and most of the time PD programs continue for a few days [84]. Other professional development opportunities are mostly paid by teachers themselves. Some of the private schools are conducting their own professional development programs for their teachers or covering the fees.

2.2 Framework of the study

This study is an outcome of TUSIAD STEM project which was started to develop a sustainable teacher professional development program to enable young science and mathematics teachers with a leadership potential to design, design innovative learning environments within the STEM: Integrated Teaching Framework and gain the confidence to share their learning-centered experiences with their colleagues.

In Figure 2.2, STEM Integrated Teaching Framework (ITF), adopted in this study, created by Çorlu is shown [85]. The main disciplines of STEM education; science, technology, mathematics and engineering are placed around the core, authentic problems of knowledge society (APoKS) [86].

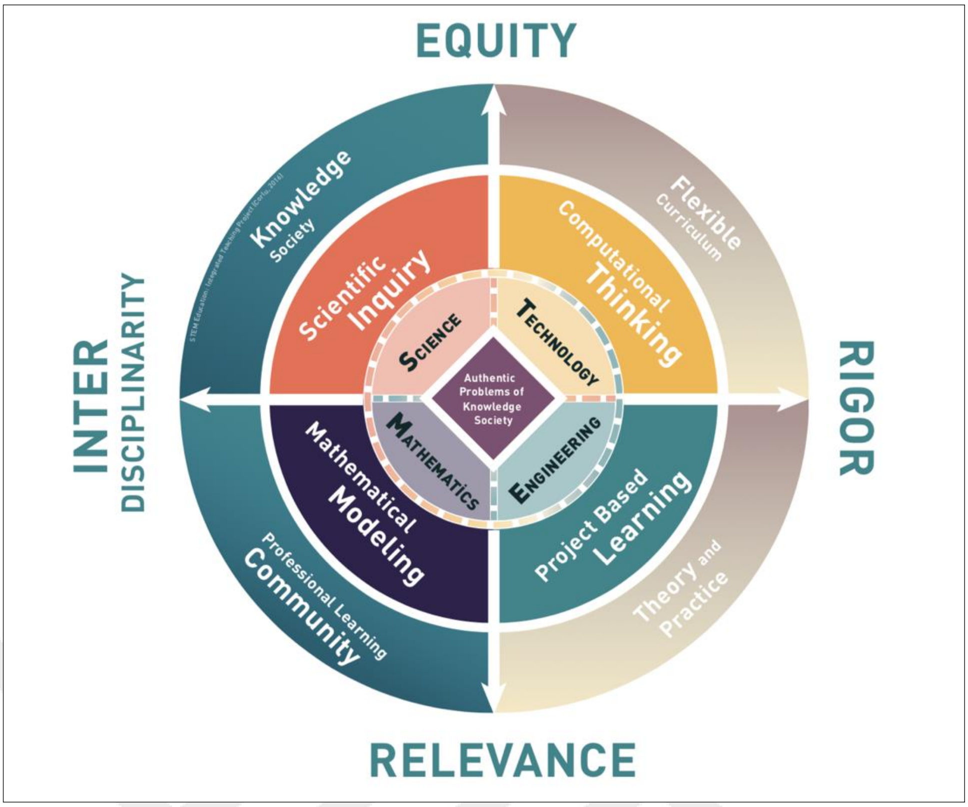

Figure 2.2 STEM Integrated Teaching Framework [85]

The middle ring circling the core indicates the cognitive processes for each discipline, respectively scientific inquiry for science, computational thinking for technology, project-based learning for engineering and mathematical modeling for mathematics. The outer ring circling the cognitive processes are the expected outcomes, knowledge society, flexible curriculum, theory and practice and professional learning community. Lastly, the arrows are pointing out the principles, equity, rigor, relevance and interdisciplinarity.

The cognitive processes which are essential to this study to specify the outlines of the framework of interdisciplinary STEM education. Thus, next few subtopics are explaining the operational definition of scientific inquiry, computational thinking, project based-learning and mathematical modeling in STEM education context.

2.2.1 Scientific Inquiry

The inclusion of scientific methods and scientific inquiry (SI) has been one of the goals of science education for a long time [87, 88]. One of the main reasons of this is scientific inquiry-based classroom activities were found to promote deep understanding of science embedded in the everyday world and develop critical thinking skills [89, 90]. The processes of scientific method such as: making observations, asking questions, forming a hypothesis, conducting an experiment, analyzing the data and drawing a conclusion, enable the students to construct knowledge like a scientist [91].

In the companion document, Inquiry and the National Science Education Standards, published by NRC, five essential steps for scientific inquiry were presented. These steps start with engaging students by scientifically oriented questions, encouraging students to develop and evaluate explanations by giving priority to sound evidence, directing students towards scientific explanations, assisting students to evaluate their explanations and letting students to communicate and justify their proposed explanations [92].

While creating a STEM lesson plan, ITF proposes to form authentic problems of knowledge society (APoKS), these problems are relevant to today's world, open-ended questions with multiple explanations [85]. The five steps of scientific inquiry can be easily followed in an interdisciplinary manner in STEM classes.

2.2.2 Computational thinking

Computational thinking (CT) was first introduced by Seymour Papert in 1980 [93]. The term became popular after Wing published an article in 2006 and ever since computational thinking has been studied thoroughly by many researchers [94-97]. Computational thinking includes practices fundamental to computing and computer science such as problem representation, abstraction, decomposition, simulation, verification, and prediction [98]. These practices are also essential to scientific and mathematical disciplines [95].

Moreover, studies show that possible outcomes of computational thinking are reasoning at multiple levels of abstraction, mathematical and design-based thinking, also using these kinds of reasoning for contextual problem solving [99-101]. Computational thinking, counted among the skills of the 21st century, is one of the main cognitive processes of STEM education.

ITF prioritizes the process and product harmony in computational thinking [85]. The lessons planned accordingly requires students to follow steps such as formulating the problem, organizing the data they have obtained as a result of their research, modeling the data or making abstraction with techniques such as simulation, step-by-step planning of solutions, choosing the most appropriate solution to achieve the purpose, and generalizing and transferring the problem-solving process for future problems [102].

Undergraduate and graduate programs opened in the recent years such as bioinformatics, computational statistics, chemometrics and neuroinformatics, are the testament of the importance and contribution of computational thinking to interdisciplinary studies [102].

2.2.3 Project-based Learning

Project-based learning (PBL) defined as an approach to learning which is student-driven and teacher-facilitated [103]. Many studies support project-based learning as a tool to engage students in real-world tasks, and to lead students to become better researchers, problem solvers, and higher-order thinkers, because students themselves construct knowledge on their own and

build on their background knowledge [103, 104]. Moreover, Bell argued that the effective and active learning process of project-based learning are developed by taking into consideration of students' various learning styles and preference. Capraro et al. introduced ill-defined task concept into project-based learning and defined project-based learning as an ill-defined task within a well-defined outcome which requires students to solve various problems and to assess by adding accountability to the various concepts of different STEM disciplines [105]. The collaboration feature of project-based learning enables students to work as a group to solve authentic and interdisciplinary issues, besides the ill-defined nature of STEM PBL facilitates problem-solving skills, higher order thinking skills and increased content learning [104, 105].

Authentic problems of knowledge society (APoKS) in ITF, which are inspired by ill-defined tasks of project-based learning, are essential to the inquiry process. APoKS are directly related to the real-world, 21st century and open to different solution with some limitations planned by the teacher [85].

2.2.4 Mathematical Modeling

Mathematical modeling is defined as by Blum in 2009 as translations between reality and mathematics [106]. Garfunkel and Montgomery redefined mathematical modeling in 2016 as "a process that uses mathematics to represent, analyze, make predictions or otherwise provide insight into the real-world phenomena" [107]. Mathematical modeling encourages students to understand the world better, supports students' mathematics learning, contribute development of various mathematical competencies and skills and contribute to students' holistic perception of mathematics [106]. Thus, it is assumed that by mathematical modeling, mathematics becomes more meaningful to students, concept formation, comprehension, and retaining will be fostered. STEM ITF regards all the efforts of interpreting complex and unfamiliar data, imposing a mathematical construction on a complex real-world situation by using mathematical modeling processes.

The report of OECD on PISA 2016 results exhibits the descriptions of the proficiency levels in mathematics. The competence level goes from 1 to 6, at level 6 students can conceptualize, generalize, and utilize information based on their investigations and modeling of complex problem situations [108]. The level 6 students' abilities to link different information sources and representations and to translate among them flexibly, demonstrates the significance of mathematical modeling. Yet, some researchers reported that modeling is also difficult for teachers, the possible causes were also addressed as the need for real-world knowledge is and the unpredictable nature of teaching in these settings [106,109,110].

CHAPTER 3

METHODOLOGY

The purpose of this present study is to examine factors related to the quality of lesson plans of teachers who participated in a teacher professional development program. The methodology used in the study is purely quantitative. The quantitative method is used by researchers to clarify a phenomenon through carefully designed and controlled data collection and analysis [111].

In this study, quantitative research method is used to investigate the current status of the quality of STEM lesson plans and also the relationship between technology and engineering integration on STEM lesson plans of mathematics and science teachers. In concordance with the type of research method, correlational design was followed; this research design involves collecting data to determine the degree to which a relationship exists between two or more variables [111].

3.1 Research Design and Procedure

TUSIAD STEM project started with the initiative of Turkish Industry and Business Association (TUSIAD) STEM working group. The required funds were supplied by the companies which are TUSIAD members; Intel Turkey, Zorlu Group, Dow Chemicals and, Lav. The principal investigator of TUSIAD STEM project was Assoc. Prof. Dr. M. Sencer Çorlu, and the project was hosted by Bahçeşehir University BAUSTEM Center. The project was started in September 2018 and planned to be a sustained PD program lasting for 6 months. The timeline of the project is in Table 3.1. The official letter from TUSIAD addressing MoNE can be seen in Appendix-A. Additionally the official approval form regarding TUSIAD STEM project by the Ministry of Education’s General Directorate of Innovation and Education Technologies (YEGITEK) was added to

Appendix-B. The official letter from TUSIAD addressing MoNE can be seen in Appendix-A.

Table 3.1 Timeline of TUSIAD STEM Project

Date	**Activity**
September 15, 2016	TUSIAD STEM Project was started.
October 20, 2016	Project information session was held in Istanbul-Uskudar.
October 31, 2016	Ministry of National Education sent the notice to schools. (Appendix-B)
November 1, 2016	Online application was opened.
November 16, 2016	Project information session was held in Hatay-Payas.
December 4, 2016	Online application was closed.
December 16, 2016	Attendee list was announced.
December 24-25, 2016	First face-to-face STEM workshops were held simultaneously in Istanbul and Hatay.
January 6, 2017	Deliveries of TUSIAD STEM kit were completed.
January-March, 2017	Teachers participated in two webinars and completed their first STEM lesson implementation.
March 11-12, 2017	Second face-to-face STEM workshops were held in Istanbul and Hatay.
March-May, 2017	Teachers participated two in webinars, created their authentic STEM lesson plans and implemented in their classes.
June 3-4, 2017	TUSIAD STEM fair was held in Istanbul and Hatay.

Additionally, the official approval form regarding TUSIAD STEM project by the Ministry of Education’s General Directorate of Innovation and Education Technologies (YEGITEK) was added to Appendix-B. Before the application period ended, information sessions both in Istanbul and Hatay held. The reason behind the chosen destinations was both logistics and the aspiration of reaching teachers from the northwestern region and southeastern regions of Turkey. The applications were received through an online platform. At the end of the application process 178 applications were submitted. The designated quota for the participant teachers for this project was 40, due to factors like effective face-to-face workshops and funding limitations.

40 teachers were selected out of 178 applications based on their content knowledge, educational background, enthusiasm for participating PD programs and STEM knowledge. The workshops were planned as different STEM lesson plans, taking into consideration of the science and mathematics curricula of 5th and 6th grades. At the end of this content development process six authentic STEM lesson plans were created. The themes of the lesson plans were;

(1) making thermos out of recycled materials,
(2) problem solving in urban transformation projects,
(3) building solar cars,
(4) creating smart schools by programming printed circuit boards,
(5) making tessellations with handmade play dough,
(6) designing a perfume bottle.

These STEM lesson plans have been edited, thus the TUSIAD STEM teacher guide was formed. Necessary materials to implement these plans were supplied and STEM kits were prepared to deliver one kit to each participant teacher. The contents of the STEM kit were added to Appendix-C.

First face-to-face workshops were held in Istanbul and Hatay on December 24-25, 2016. At the beginning of the workshops, teachers signed the research consent form (Appendix-D) indicating that they transferred their copyrights to the PI of project. During workshops, teachers experienced four of the prepared lesson plans. After the workshops, teachers received their kits and guides.

Starting from the day of the first face-to-face workshop, user accounts were created for the participant teachers in the learning management system, “itslearning”. Thus, the teachers were able to ask questions, access necessary documents, upload audiovisual resources, and easily follow the schedule of webinars.

The second face-to-face workshop was held on March 11-12, 2017. This gathering was aimed to conduct brainstorming on what went well and what went wrong in the classroom during the implementation of STEM lesson plans as well as giving feedback on new ideas to create authentic STEM lesson plans.

At the end of the project, 32 teachers submitted their lesson plans, prepared posters and presented their lesson plans in TUSIAD STEM fair with the participation of their colleagues, students and, the local community.

3.2 Participants

The participants of this study were 32 science and mathematics teachers who teach 5th and 6th grades. The descriptive information is shown in Table 3.2.

Table 3.2 Descriptive Data of the Participants

Teacher Characteristics	Frequency	Percent (%)
Gender		
Male	8	25.0
Female	24	75.0
Discipline		
Mathematics	14	43.8
Science	18	56.3
Province		
Istanbul	21	65.6
Hatay	11	34.4
Undergraduate Faculty		
Faculty of Education	28	87.5
Faculty of Natural Sciences	4	12.5
Latest Degree		
B.A.	23	71.9
M.A. or M.S.	8	25
Ph.D.	1	3.1

The majority of the teachers, 22 teachers were from Istanbul. Regarding the population density in Istanbul, the most crowded city of Turkey, teachers' distribution could be understood. 11 teachers were from Hatay, a city in southern Turkey, on the eastern Mediterranean coast, which is also bordered by Syria. Female teacher are three times of the male teachers.

In terms of gender, female participants which constituted 75% of the population, were threefold of the male participants. 44% of the participants was mathematics teachers, 56%

of them were science teachers. 87.5% of the population graduated from Faculty of Education. Only 4 out of 32 teachers were graduates of Faculty of Natural Sciences. 28% of the population was pursuing higher degrees.

3.3 Data Collection

In this study, data has been collected on the LMS system, the participants submitted their authentic STEM lesson plans at the end of the five-month-long professional development program. The template plan was shared with the teachers also the teacher guide followed the same pattern as the template lesson plan. The template STEM lesson plan was added in Appendix-E. It has been developed within the scope of Integrated Teaching Project (ITP). The submitted lesson plans follow 5E lesson plan scheme;

Target Objectives (Main discipline objectives, Other STEM discipline objectives, Social product objectives)

Materials

Resources and References

Assessment and Evaluation (Rubrics, Other assessment tools)

APoKS (Authentic Problems of Knowledge Society) (Limitations, Jobs and Responsibilities)

Lesson Content (Engagement, Exploration, Explanation, Extension, Evaluation)

For technology and engineering integration the aims and the use of objectives were taken into consideration. Not only the rubric, but also the overall lesson plans analyzed. Thereby, the STEM lesson plans were main data source of this study.

3.4 Instrument

The instrument to assess the STEM lesson plans is STEM lesson plan rubric (see Appendix F). This rubric was used to create a framework for assessing lesson plans summatively. During the workshops and on the online platform, this rubric was shared with the participant teachers to enable them to be aware of the assessment criteria. Seven domains including; Target objectives, Materials and Resources, Engagement, Exploration, Explanation, Extension and, Evaluation were present in the rubric. These seven domains cover a continuum from 0 to 10. Hence for the lesson plan quality score; the maximum score is 70 and the minimum score is 0.

Also, the scores fall in three categories; development needed, acceptable, target reached. As McGehee and Griffith suggests categories do not give adequate information, so during the assessment period, two raters chose to score over 10 points for each domain rather than using categories [112].

3.5 Data Analysis

For data analysis, the scores of the lesson plans utilized as “lesson plan quality”. This score was the dependent variable of the study. Independent variables were determined as technology integration, engineering integration and discipline. To analyze the data gathered from STEM lesson plans analysis of variance ANOVA was used. By using ANOVA, some certain assumptions made; independence of cases, normality – the distributions of the residuals are normal and finally equality (or "homogeneity") of variances, which is called homoscedasticity [113]. The aim of using ANOVA was to test differences between means of the lesson plan scores of the ones who integrated technology in their lessons and also the ones who integrated engineering in their lessons. Again, the means of the lesson plans of the participant teachers from different disciplines were expected to tell the general trend and explain some part of the lesson plan quality data.

Moreover, the mean squares, power estimates, partial eta squares and effect size (Cohen’s d) were reported as a result of the ANOVA run on the statistical analysis software, SPSS.

For technology and engineering integration all lesson plans were gathered together and the key points of integration such as objectives, content knowledge, application concerning technology and engineering noted down. Afterwards these notes categorized, the categories of the lesson plans were organized accordingly. Five categories were reported for each discipline: technology and engineering.

3.6 Inter-rater Reliability

Inter-rater reliability calculations were done based on the first and second raters’ decisions regarding the rubric scores. The STEM lesson plan rubric includes seven different domains; target objectives, materials and resources, engagement, exploration, explanation, extension and finally evaluation.

For 32 STEM lesson plans every one of them was evaluated in seven different domains, a total of 224 scores was given. Cohen's kappa coefficient was found 0.81 (see Appendix-G), this correlational coefficient demonstrated a strong agreement between the first and the second rater [114]. Although the agreement level was found out to be strong, after rejoining and negotiating on the given score by two raters, the mean values of lesson plan scores were used during the analysis.

CHAPTER 4

RESULTS AND DISCUSSION

The overall intention of the study was to see if there was a significant difference between the quality of STEM lesson plans of the participants teachers who integrated technology or engineering into their lesson plans.

The findings for this research was presented in the following sections. The first section is presenting the descriptive statistics of the quantitative data in order to help contextualize the findings derived from the data. The next section is focusing on the findings from the ANOVA test.

4.1 Descriptive Statistics

Frequencies of categorical variables (discipline, technology integration and engineering integration) which were used in the study is presented in Table 4.1.

According to the descriptive statistics, majority of the teachers (84%) chose to integrate engineering rather than technology. 65% of the teachers chose to integrate technology. 14% of mathematics teachers integrated technology, while the rest, 86% choose not to use technology in their lesson plans. 50% of science teachers integrated technology, and the other half, 50% chose not to use technology in their lesson plans. 79% of mathematics teachers integrated engineering into their lesson plans, and 21% of the mathematics teachers did not use engineering. 89% of science teachers integrated engineering while 11% of the science teachers did not. 11 teachers out of 32 integrated both technology and engineering in their lesson plans. The entire population of participants integrated either technology or engineering or integrated both.

Table 4.1 Frequencies

	Frequency	Percent	Valid Percent	Cumulative Percent
Mathematics	14	43.8	43.8	43.8
Science	18	56.3	56.3	100.0
Total	32	100.0	100.0	
No Technology Objectives	21	65.6	65.6	65.6
Technology Objectives	11	34.4	34.4	100.0
Total	32	100.0	100.0	
No Engineering Objectives	5	15.6	15.6	15.6
Engineering Objectives	27	84.4	84.4	100.0
Total	32	100.0	100.0	

In the Table 4.2 and 4.3, the technology integration categories, engineering integration categories and the frequencies were presented. The categories are getting more complex from top to bottom.

Table 4.2 Technology Integration Categories

	Frequency	Percent	Valid Percent	Cumulative Percent
No Technology Integration	14	43.8	43.8	43.8
Getting Information	5	15.6	15.6	59.4
Utilization of Tech Devices	1	3.1	3.1	62.5
Data Interpretation	5	15.6	15.6	78.1
Representation	1	3.1	3.1	81.3
Analysis and Creation	6	18.8	18.8	100.0
Total	32	100.0	100.0	

About technology integration 14 teachers did not choose to integrate technology, 5 out of 32 teachers used technology with the sole purpose of accessing information via internet connection. Only one teacher utilized technological device, this case was about taking a measurement with a technological laboratory equipment. 5 other teachers were also using technological devices, but they also interpreted the data collected via these devices. Additionally, one teacher added data representation to interpretation. 6 of the teachers reached analysis and creation category with their lesson plans. They programmed an electronical tool to create a solution to the authentic problem of knowledge society (APoKS) with their students.

Table 4.3 Engineering Integration Categories

	Frequency	Percent	Valid Percent	Cumulative Percent
No Engineering Integration	5	15.6	15.6	15.6
Accessing Information	5	15.6	15.6	31.3
Grasping the Concept	3	9.4	9.4	40.6
Creating Different Ideas	3	9.4	9.4	50.0
Planning and Prototyping	14	43.8	43.8	93.8
Testing	2	6.3	6.3	100.0
Total	32	100.0	100.0	

About engineering integration, quite many teachers integrated engineering into their lessons. 5 of 32 teachers accessed information concerning an engineering problem. They used different means of information resources. 3 teachers enabled their students to graph the concept, they approached the problem from different aspects. Another 3 teachers not only let their students to grasp the concept but also encouraged their students to create different ideas for the solution of the problem. 14 of the teachers planned and implemented a planning phase to build prototypes. Thus, prototypes for an engineering problem were developed in the class. Only 2 of the teachers reserved time for testing so that students observed what went well and which parts should be developed.

In Table 4.4, descriptive statistics of lesson plans scores were presented. The STEM lesson plan scores of the participant teachers were analyzed in terms of different disciplines and integration of technology and engineering.

The dependent variable in this study is lesson plan score, independent variables are discipline, technology integration and engineering integration. Among the teachers who did not integrate engineering and technology, there are three mathematics and two science teachers. In terms of their scores, mathematics teachers’ mean (41) is three points higher than science teachers’ mean (38). Among the teachers who integrated both engineering and technology, there are two mathematics and nine science teachers. In terms of their scores, science teachers’ mean (50) is six points higher than mathematics teachers’ mean (44).

Table 4.4 Descriptive Statistics

Dependent Variable: Lesson Plan Score

Technology Integration	Engineering Integration	Discipline	Mean	Std. Deviation	N
No Technology Objectives	No Engineering Objectives	Mathematics	41.667	7.0770	3
		Science	38.000	11.3137	2
		Total	40.200	7.8150	5
	Engineering Objectives	Mathematics	45.500	4.6570	9
		Science	46.714	5.1223	7
		Total	46.031	4.7380	16
	Total	Mathematics	44.542	5.2806	12
		Science	44.778	7.1024	9
		Total	44.643	5.9606	21
Technology Objectives	Engineering Objectives	Mathematics	44.500	2.1213	2
		Science	50.167	2.4238	9
		Total	49.136	3.2256	11
	Total	Mathematics	44.500	2.1213	2
		Science	50.167	2.4238	9
		Total	49.136	3.2256	11
Total	No Engineering Objectives	Mathematics	41.667	7.0770	3
		Science	38.000	11.3137	2
		Total	40.200	7.8150	5
	Engineering Objectives	Mathematics	45.318	4.2384	11
		Science	48.656	4.0936	16
		Total	47.296	4.4012	27
	Total	Mathematics	44.536	4.8929	14
		Science	47.472	5.8473	18
		Total	46.187	5.5660	32

4.2 Findings of Inferential Data Analysis

In Table 4.5, test of between-subjects effects was presented. According to the analysis, there is no significant difference on the lesson plan scores of mathematics and science teachers. Again, there is no significant difference on the lesson plan scores of the teacher who integrated technology and who did not integrate technology into their lesson plans.

Moreover, there is a significant difference on the lesson plan scores of teachers in terms of integrating engineering into their lesson plans. Partial eta squares were indicated for discipline, technology integration and engineering integration respectively as 0.07, 0.11 and 0.192.

Table 4.5 Tests of Between-Subjects Effects

Dependent Variable: Lesson Plan Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	349.780[a]	5	69.956	2.979	.030	.364
Intercept	32225.497	1	32225.497	1372.207	.000	.981
Discipline	4.508	1	4.508	.192	.665	.007
Technology Integration	6.952	1	6.952	.296	.591	.011
Engineering Integration	144.801	1	144.801	6.166	.020	.192
Discipline * Technology Integration	22.915	1	22.915	.976	.332	.036
Discipline * Engineering Integration	21.911	1	21.911	.933	.343	.035
Technology Integration * Engineering Integration	.000	0	.	.	.	.000
Discipline * Technology Integration * Engineering Integration	.000	0	.	.	.	.000
Error	610.595	26	23.484			
Total	69225.500	32				
Corrected Total	960.375	31				

a. R Squared = .364 (Adjusted R Squared = .242)

For effect size comparison, Cohen's d and effect size calculations were made. For mathematics and science disciplines Cohen's d was found 0.54 and effect-size r was found 0.26. For technology integration Cohen's d was found 0.93 and effect-size r was found 0.42, for engineering integration Cohen's d was found 1.18 and effect-size r was found 0.49.

4.3 Discussion

This present study focused on the effect of integrating technology and engineering into mathematics and science classrooms on lesson plans scores. The following research questions were investigated:

Is there a statistical significant main effect of technology and engineering use on the quality of 5th and 6th grade mathematics and science lesson plans?

Is there a statistical significant main effect of the discipline of teachers on the quality of lesson plans?

Is there a statistical significant interaction effect of technology and engineering use and discipline on the quality of lesson plans?

In what ways and to what extent do teachers utilize technology and engineering in their STEM lesson plan?

In order to examine these questions STEM lesson plans of teacher collected after a rigorous STEM professional development program teacher. These lesson plans were utilized as a data source. Descriptive and inferential data analysis were conducted.

Table 4.6 Categories of Integration

Technology Integration Categories	Engineering Integration Categories
No Technology Integration	No Engineering Integration
Getting Information	Accessing Information
Utilization of Technological Devices	Grasping the Concept
Data Interpretation	Creating Different Ideas
Representation	Planning and Prototyping
Analysis and Creation	Testing

The findings indicate that there was no significant interaction effect of technology integration and different disciplines. However, engineering integration showed a significant interaction effect. The STEM lesson plan scores of teachers who integrated engineering into their lessons were higher than the rest. Also, the integration process and ways of integration were crucial. The study also investigated in which manners teachers made use of technology and engineering. In Table 4.6 the categories shaped by teachers' lesson plans were pointed out.

The descriptive analysis showed that majority of the teachers, 84% of the population chose to integrate engineering rather than technology. This could be due to their comfort zones or due to the fact that use of technological devices requires experience. Moreover, trial and error nature of engineering could have created a secure classroom environment for teachers. The indicated results of high frequency in engineering integration is quite unconventional since engineering does not have a curriculum in K-12 levels in Turkey, there are no teachers responsible for engineering discipline present at the schools to collaborate. Whereas there is a compulsory information technologies curriculum in Turkey for 5th and 6th grades and teachers are present at every school to collaborate on the interdisciplinary aspects and intersections of both disciplines. The deduction from this particular study is that technology and/or engineering integration is independent from the available teacher colleagues of different disciplines.

The effect of engineering integration on STEM lesson plan quality which was found out to be significant can also be explained with the easy access to materials needed for project-based learning activities. Only some privileged public schools can supply technological devices for the teachers and students, although most private schools supply both internet connection and technological devices like iPads, laptops or desktop computers. The TUSIAD STEM kit delivered to teachers was consisting of hardware, it is quite apparent that to be able to integrate technology into mathematics and science a teacher should at least have several computers ready with internet connection. These outside factors could have an impact on the effect of STEM lesson plan quality.

4.4 Implications

This present study aimed to reveal one aspect of teacher professional development program in Turkish context which is the effect of integrating technology and engineering on lesson plan quality. In this regard, TUSIAD STEM project provided the suitable conditions for data collection and interpretation. There needs to be sufficient programs because teacher professional development programs support practice, quality resources, and encourage communication between knowledgeable colleagues. However, technology and engineering need to be nested within a framework for effective professional development.

Based on the finding of this study, researchers can focus on the integration of technology and engineering and conduct more research in the coming years. Sustained teacher professional development programs and the outcomes of these programs in terms of interdisciplinarity is one quite invaluable when the obvious shift from hyperspecialization to transdisciplinarity taken into account. The extent of integration of technology and engineering in lesson plans of teachers from various backgrounds and disciplines can be studied in larger populations. Finally, the reasons of why technology integration did not affect overall quality of STEM lesson plans seem to be worthwhile study to investigate.

4.5 Limitations

There is an explicit gap about teacher professional development programs, even though the need for teacher professional development programs are somehow met by distance education alternatives and projects specifically designed for teachers by funding from the Scientific and Technological Research Council of Turkey (TUBITAK) under the name of science and society innovative education practices. Accessed results and findings of high-quality sustained teacher professional development programs in Turkish is highly limited. So, this is a limitation in terms of comparing with other studies in Turkish context.

As represented in Table 4.6, the categories of integration were a result of the study. When the frequencies investigated, there was not a proper distribution to run statistical tests. This was also due to relatively small sample size; hence the study can be replicated in the near future to explain the effects of integration in terms of different categories.

Another limitation is the sample size, because TUSIAD STEM project was funded by companies there was a limit for the number of the participants. There was a selection period and methodology. The teachers participated in the program were already enthusiastic about creating new ideas, accessing many resources and developing authentic lesson plans.

REFERENCES

[1] OECD, (2008). 21st Century Learning: Research, Innovation and Policy Directions from recent OECD analyses, OECD, Paris.

[2] Loepp, F.L., (1999). “Models of curriculum integration”, Journal of Technology Studies, 25(2):21-25.

[3] Berlin, D.F. and Lee, H., (2005). “Integrating science and mathematics education: Historical analysis”, School Science and Mathematics, 105(1):15–24.

[4] Drake, M.S. and Burns, C.B., (2004). Meeting standards through integrated curriculum, Association for Supervision and Curriculum Development, Alexandria.

[5] Kıray, S.A., (2012). “A new model for the integration of science and mathematics: The balance model”, Energy Education Science and Technology Part B: Social and Educational Studies, 4(3):1181-1196.

[6] Unesco Centre Européen pour l’Enseignement Supérieur (CEPES), (1983). Interdisciplinarity in higher education, Bucharest.

[7] Valtorta, C.G. and Berland, L.K., (2015). "Math, Science, and Engineering Integration in a High School Engineering Course: A Qualitative Study," Journal of Pre-College Engineering Education Research (J-PEER), 5(1):15-29.

[8] Dewey, J., (1938). Experience and education. Simon and Schuster, New York.

[9] Kıray, S.A., (2010). İlköğretim ikinci kademede uygulanan fen ve matematik entegrasyonunun etkililiği, Ph.D. Dissertation, Hacettepe University Institute of social Sciences, Ankara.

[10] Gordon, M., (2016). “Why Should Scholars Keep Coming Back to John Dewey?”, Educational Philosophy and Theory, 48(10):1077-1091.

[11] Miettinen, R., (2000). “The concept of experiential learning and John Dewey's theory of reflective thought and action”, International Journal of Lifelong Education, 19(1):54-72.

[12] Piaget, J., (1972). "Intellectual Evolution from Adolescence to Adulthood", Human Development, 15:1-12.

[13] Dewey, J., (1939). Türkiye maarifi hakkında rapor [Report about Turkish education], Devlet Basımevi, İstanbul.

[14] Carroll, J.B., (1989). “The Carroll Model: A 25-Year Retrospective and Prospective”, Educational Researcher, 18(1):26-31.

[15] Klein, J.T., (1990). Interdisciplinarity: History, theory and practice, Wayne State University Press, Detroit.

[16] Robinson, L., (1994). “Interdisciplinary planning and instruction”, Interdisciplinary Teaching and Learning Workshop, 30 May 1994, Tuscaloosa.

[17] Lonning, R.A. and DeFranco, T.C., (1997). “Integration of science and mathematics: A theoretical model”, School Science and Mathematics, 97(4):212-215.

[18] Zemelman, S., Daniels, H. and Hyde, A., (2005). Best practice: New standards for teaching and learning in America’s school (3rd Edition), Portsmouth, NH: Heinemann.

[19] National Science Board, (2015). Revisiting the Stem Workforce: A Companion to Science and Engineering Indicators, National Science Foundation, Arlington.

[20] Sanders, M., (2009). “STEM, STEM education, STEMmania”, The Technology Teacher, 68(4): 20–26.

[21] Rosicka, C., (2016). From Concept to Classroom Translating STEM education Research into Practice, Australian Council for Educational Research, Melbourne.

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

[23] Bybee, R. W. (2010) “What is STEM Education?”, Science, 329(5995): 996.

[24] Stohlmann, M., Moore, Tamara, J. and Roehrig, G.H. (2012). “Considerations for Teaching Integrated STEM Education”, Journal of Pre-College Engineering Education Research (J-PEER): 2(1).

[25] OECD, (2008). Encouraging Student Interest in Science and Technology Studies, OECD, Paris.

[26] OECD, (2010). Learning for jobs, OECD, Paris.

[27] Kärkkäinen, K. and Vincent-Lancrin, S., (2013), Sparking Innovation in STEM Education with Technology and Collaboration: A Case Study of the HP Catalyst Initiative, OECD Education Working Papers No: 91, OECD Publishing.

[28] Corlu, M.S., Capraro, R. and Capraro, M., (2014). “Introducing STEM Education: Implications for Educating Our Teachers for the Age of Innovation”, Eğitim ve Bilim, 39(171):74-85.

[29] Furner, J.M. and Kumar, D.D., (2007). “The Mathematics and Science Integration Argument: A Stand for Teacher Education”, Eurasia Journal of Mathematics, Science and Technology Education, 3(3):185-189.

[30] Honey, M., Pearson, G., Schweingruber, H., (eds.) (2014). “STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research”, National Academy Press, Washington.

[31] English, L.D., (2016). “STEM education K-12: perspectives on integration”, International Journal of STEM Education, 3(3):1-8.

[32] European Commission, (2014a). EU Skills Panorama, Science and Engineering Professionals Analytical Highlight, prepared by ICF and CEDEFOP for the European Commission, http://skillspanorama.cedefop.europa.eu/en, 12 June 2018.

[33] European Commission, (2014b). EU Skills Panorama, Science and engineering associate professionals Analytical Highlight prepared by ICF and Cedefop for the European Commission, http://skillspanorama.cedefop.europa.eu/en, 12 June 2018.

[34] OECD, (2018). The future of education and skills Education 2030, OECD, Paris.

[35] Blackley, S. and Howell, J., (2015). "A STEM narrative: 15 years in the making", Australian Journal of Teacher Education, 40(7):102–112.

[36] Becker, K. and Park, K., (2011). "Integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students learning: A meta-analysis", Journal of STEM Education, 12(5):23–37.

[37] English, L. and King, D., (2015). "STEM learning through engineering design: Fourth-grade students' investigations in aerospace", International Journal of STEM Education, 2(1).

[38] Everett, L., Imbrie, P. and Morgan, J., (2000). "Integrated curricula: Purpose and design", Journal of Engineering Education, 89(2):167–175.

[39] Hanover Research, (2012). Best practices in elementary STEM programs, Hanover Research, Washington.

[40] Burrows, A. and Slater, T., (2015). "A proposed integrated STEM framework for contemporary teacher preparation", Teacher Education and Practice, 28:318–330.

[41] DeBacker, T. and Nelson, R., (2000). "Motivation to learn science: Differences related to gender, class type, and ability", The Journal of Educational Research, 93(4):245–254.

[42] Asunda, P.A., (2014). "A conceptual framework for STEM integration into the curriculum through career and technical education", Journal of STEM Teacher Education, 49(1):3–16.

[43] Andreevna, N. and Sergievskii, V., (2014). "Approach to Problems of Interdisciplinary Education", Procedia Social and Behavioral Sciences, 128:489-492.

[44] Berlin, D.F. and White, A.L., (1992). "Report from the NSF/SSMA Wingspread Conference: A Network for Integrated Science and Mathematics Teaching and Learning", School Science and Mathematics, 92(6):340-342.

[45] Sunal, D. and Furner, J.M., (1995). "Teaching Mathematics and Science Not Mathematics or Science", NASA Teacher Enrichment Program Mid-Year Teacher Education Math/Science Integration Workshop, 18 March 1995, Huntsville.

[46] Lonning, R.A. and DeFranco, T.C., (1994). "Development and Implementation of an Integrated Mathematics/Science Preservice Elementary Methods Course", School Science and Mathematics, 94(1):18-25.

[47] Davison, D.M., Miller, K.W. and Metheny, D. L., (1995). "What Does Integration of Science and Mathematics Really Mean?", School Science and Mathematics, 95(5):226-230.

[48] Vasquez, J., Sneider, C. and Comer, M., (2013). STEM Lesson Essentials, Grades 3–8: Integrating Science, Technology, Engineering, and Mathematics, Heinemann, Portsmouth.

[49] Jacobs, H., (1989). Interdisciplinary Curriculum: Design and Implementation, Association for Supervision and Curriculum Development, Alexandria.

[50] Gero, A., (2017). "Students' attitudes towards interdisciplinary education: a course on interdisciplinary aspects of science and engineering education", European Journal of Engineering Education, 42(3):260-270

[51] Romrell, D., Kidder, L.C. and Wood, E., (2014). "The SAMR model as a framework for evaluating mLearning", Online Learning, 18(2):1-15.

[52] National Academy of Engineering and National Research Council, (2009). Engineering in K-12 Education: Understanding the Status and Improving the Prospects, The National Academies Press. Washington.

[53] Zucker, A., Tinker, R., Staudt, C., Mansfield, A. and Metcalf, S. (2008). "Learning science in grades 3–8 using probeware and computers: Findings from the TEEMSS II project", Journal of Science Education and Technology, 17(1):42–48.

[54] Breiner, J.M., Harkness, S.S., Johnson, C.C., et al. (2012). "What is STEM? A discussion about conceptions of STEM in education and partnerships", School Science and Mathematics. 112(1):3–11.

[55] Rennie, L., Venville, G., Wallace, J.E., eds. (2012). Integrating science, technology, engineering, and mathematics: issues, reflections, and ways forward, Routledge, New York.

[56] Özcan, H. and Düzgünoğlu, H., (2017). "Fen Bilimleri Dersi 2017 Taslak Öğretim Programına İlişkin Öğretmen Görüşleri", International Journal of Active Learning (IJAL), 2(2):28-47.

[47] Bahar, M., Yener, D., Yılmaz, M., Emen, H. and Gürer, F., (2018). "2018 Fen bilimleri öğretim programı kazanımlarındaki değişimler ve fen teknoloji matematik mühendislik (STEM) entegrasyonu", Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 18(2):702-735.

[58] Villegas-Reimers, E., (2003). Teacher Professional Development: An International Review of the Literature, UNESCO International Institute for Educational Planning, Paris.

[59] Smylie, M.A., Allensworth, E., Greenberg, R.C., Harris, R. and Luppescu, S., (2001). Teacher professional development in Chicago: Supporting effective practice. Consortium on Chicago School Research, Chicago.

[60] Saunders, W.M., Goldenberg, C.N. and Gallimore, R., (2009). "Increasing achievement by focusing grade-level teams on improving classroom learning: A prospective quasi-experimental study of Title I schools", American Educational Research Journal, 46:1006–1003.

[61] Cohen, D.K. and Hill, H.C., (2000). "Instructional policy and classroom performance: The mathematics reform in California", Teachers College Record, 102:294–343.

[62] Czerniak, C.M., Beltyukova, S., Struble, J., Haney, J.J. and Lumpe, A.T., (2005). “Do you see what I see? The relationship between a professional development model and student achievement”, In Yager, R.E. (Ed.), Exemplary science in grades 5–8: Standards-based success stories, 13–43, NSTA Press, Arlington.

[63] Loucks-Horsley, S., Love, N.B., Stiles, K.E. and Mundy, S.E., (2003). Designing professional development for teachers of science and mathematics, Corwin Press, Thousand Oaks.

[64] Schneider, R.M., Krajcik, J., Marx, R.W. and Soloway, E., (2002). “Performance of students in project-based science classrooms on a national measure of science achievement”, Journal of Research in Science Teaching, 39:410–422.

[65] Berlin, D.F., White, A.L., (1994). “A Longitudinal Look at Attitudes and Perceptions Related to the Integration of Mathematics, Science, and Technology Education”, School Science and Mathematics, 112(1).

[66] Frykholm, J. and Glasson G., (2005). “Connecting science and mathematics instruction: pedagogical context knowledge for teachers”, School Science and Mathematics 105(3):127–141.

[67] Metzner, N., (2011). “High School Engineering and Technology Education Integration through Design Challenges”, Journal of STEM Teacher Education, 48(2), 103.

[68] National Academies, (2007). Rising above the gathering storm: Energizing and employing America for a brighter economic future, National Academies Press, Washington.

[69] Corlu, M.S., Callı, E., (eds.) (2017). Fen, Teknoloji, Mühendislik ve Matematik (STEM): Kuram ve Uygulamaları, (English: STEM: Practices and Theories), Pusula, Istanbul.

[70] Ríordáina, M.N., Johnstonb, J. and Walshec, G., (2016). “Making mathematics and science integration happen: key aspects of practice”, International Journal of Mathematical Education in Science and Technology, 47(2):233-255.

[71] Honey M, Pearson G, Schweingruber H, (eds.) (2014). STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research, National Academies Press, Washington.

[72] NGSS (Next Generation Science Standards), (2015). http://www.nextgenscience.org/, 8 April 2018.

[73] Hobbs, L., (2013). “Teaching ‘Out-of-Field’ as a Boundary-Crossing Event: Factors Shaping Teacher Identity”, International Journal of Science and Mathematics Education, 11(2):71.

[74] Pillay, H., Goddard, R. and Wilss, L., (2005). “Well-being, burnout and competence: Implications for teachers”, Australian Journal of Teacher Education, 30(2):22–33.

[75] Yoon, K.S., Duncan, T., Lee, S.W., Scarloss, B. and Shapley, K.L., (2007). “Reviewing the Evidence on How Teacher Professional Development Affects Student Achievement”, US Department of Education, National Center for Education Evaluation and Regional Assistance, Washington.

[76] Capraro, R. M., Capraro, M. M., Scheurich, J. J., Jones, M., Morgan, J., Huggins, K. S., Corlu, M. S., Younes R. and Han, S., (2016). “Impact of sustained professional development in STEM on outcome measures in a diverse urban district”, The Journal of Educational Research, 109(2):181-196.

[77] Garet, M.S., Porter, A.C., Desimone, L., Birman, B.F. and Yoon, K.S., (2001). “What makes professional development effective? Results from a national sample of teachers”, American Educational Research Journal, 38: 915–945.

[78] Guskey, T.R. and Yoon, K.S., (2009). “What works in professional development?”, Phi Delta Kappan, 90:495–500.

[79] Nadelson, L.S., Callahan, J., Pyke, P., Hay, A., Dance, M. and Pfiester, J., (2013). “Teacher STEM perception and preparation: Inquiry-based STEM professional development for elementary teachers”, The Journal of Educational Research, 106:157–168.

[80] Supovitz, J.A. and Turner, H.M., (2000). “The effects of professional development on science teaching practices and classroom culture”, Journal of Research in Science Teaching, 37:63–980.

[81] OECD, (2009). Creating Effective Teaching and Learning Environments: first results from TALIS, OECD Publishing, Paris.

[82] Doganca Kucuk, Z., Asik, G. and Girgin, Ş., (2017). “Teachers’ Views on the Implementation of an Early Stem Education Program”, 12th Conference of the European Science Education Research Association (ESERA), 21-25 August 2017, Dublin.

[83] Türk, N., Kalayci, N. and Yamak, H., (2018). “New Trends in Higher Education in the Globalizing World: STEM in Teacher Education”, Universal Journal of Educational Research, 6(6):1286-1304.

[84] Sarıtepeci, M., Durak, H. and Seferoğlu, S.S., (2016). “Öğretmenlerin Öğretim Teknolojileri Alanında Hizmet-İçi Eğitim Gereksinimlerinin FATİH Projesi Kapsamında İncelenmesi”, Turkish Journal of Computer and Mathematics Education; 7(3):601-620.

[85] Corlu, M.S. and Callı, E., (eds.) (2017). Fen, Teknoloji, Mühendislik ve Matematik (STEM): Kuram ve Uygulamaları (English: STEM: Practices and Theories), Pusula, Istanbul.

[86] Corlu, M.S., Capraro, R. and Capraro, M. (2014). “Introducing STEM Education: Implications for Educating Our Teachers for the Age of Innovation”, Eğitim ve Bilim, 39:74-85.

[87] NGSS Lead State Partners, (2013). Next Generation Science Standards: For states, by states, The National Academies Press, Washington.

[88] Cakir, M., (2011). “L.B. Flick and N.G. Lederman (Eds): Scientific Inquiry and Nature of Science: Implications for Teaching, Learning, and Teacher Education.”, Science and Education, 20:381-387.

[89] Brown, A.L. and Campione, J.C., (1994). Guided discovery in a community of learners. In K. M.Gilly (Ed.), Classroom lessons: Integrating cognitive theory and classroom practice, MIT Press, Cambridge.

[90] Schneider, R.M., Krajcik, J.S., Marx, R.W. and Soloway, E., (2002). “Performance of students in project-based science classrooms on a national measure of science achievement”, Journal of Research in Science Teaching, 39(5):410-422.

[91] Corlu, M.A. and Corlu, M.S., (2012). “Scientific Inquiry Based Professional Development Models in Teacher Education”, Educational Sciences: Theory and Practice, 12(1):514-521.

[92] National Research Council (NRC), (2000). Inquiry and the national science education standards, National Academies Press, Washington.

[93] Papert, S., (1980). Mindstorms. Children, computers and powerful ideas. Basic Books, New York.

[94] Wing, J.M., (2006). “Computational Thinking”. Communications of the ACM, 49(3):33–35.

[95] Sengupta, P., Kinnebrew, J.S., Basu, S., Biswas, G. and Clark, D., (2013). “Integrating computational thinking with K-12 science education using agent-based computation: A theoretical framework”, Education and Information Technologies, 18(2):351–380.

[96] Weintrop, D., Beheshti, E., Horn, M., Orton, Kai, Jona, K., Trouille, L. and Wilensky, U., (2016). “Defining Computational Thinking for Mathematics and Science Classrooms”, Journal of Science Education and Technology, 25(1):127–147.

[97] Wilensky, U. and Reisman, K., (2006). “Thinking like a wolf, a sheep or a firefly: Learning biology through constructing and testing computational theories—An embodied modeling approach”, Cognition and Instruction, 24(2):171–209.

[98] National Research Council, (2010). Report of a workshop on the scope and nature of computational thinking, The National Academies Press, Washington.

[99] Kramer, J., (2007). “Is abstraction the key to computing?” Communications of the ACM, 50(4):36–42.

[100] Guzdial, M., (2008). “Paving the way for computational thinking”, Communications of the ACM: Education Column, 51(8).

[101] Wing, J.M., (2008). “Computational thinking and thinking about computing”, Philosophical Transactions of the Royal Society, 366: 3717–3725.

[102] Helvaci, B., Adiguzel, T. and Karadeniz, S., (2017). STEM-FeTeMM Eğitiminin Hesaplamalı Düşünme Becerilerine Yaklasimi [Approach of STEM Education to Computational Thinking Skills]. In M. S. Çorlu, and E. Çallı (Eds). STEM Kuram ve Uygulamaları, Pusula, İstanbul.

[103] Bell, S., (2010). “Project-Based Learning for the 21st Century: Skills for the Future”, The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 83(2):39-43.

[104] Gultekin, M., (2005). “The effect of project based learning on learning outcomes in the 5th grade social studies course in primary education”. Educational Sciences: Theory and Practice 5(2):548–56.

[105] Capraro, R.M., Capraro, M.M. and Morgan, J.R., (2013). STEM Project-Based Learning an Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach, Sense Publishers, Rotterdam.

[106] Blum, W. and Borromeo-Ferri, R., (2009). “Mathematical modelling: Can it be taught and learnt?”, Journal of Mathematical Modelling and Application, 1(1):45–58.

[107] Garfunkel, S.A. and Montgomery, M., (2016). GAIMME: Guidelines for Assessment and Instruction in Mathematical Modeling Education, Consortium for Mathematics and Its Applications, Philadelphia.

[108] OECD (2007). PISA 2006 - Science Competencies for Tomorrow's World, OECD, Paris,

[109] Freudenthal, H., (1973). Mathematics as an Educational Task, Reidel, Dordrecht.

110] DeLange, J. (1987). Mathematics, Insight and Meaning, Rijksuniversiteit, Utrecht.

[111] Fraenkel, J., Wallen, N. and Hyun, H. (2012). How to design and evaluate research in education (8th ed), McGraw-Hill Companies Inc, New York

[112] McGehee, J.J. and Griffith, L.K., (2001). “Large-Scale Assessments Combined with Curriculum Alignment: Agents of Change”, Theory into Practice, 40:137-144.

[113] Keselman, H.J., Huberty, C.J., Lix, L.M., Olejnik, S., Cribbie, R.A., Donahue, B., Kowalchuk, R.K., Lowman, L.L., Petoskey, M.D., Keselman J.C. and Levin J.R., (1998). “Statistical Practices of Educational Researchers: An Analysis of Their ANOVA, MANOVA, and ANCOVA Analyses”, Review of Educational Research, 68(3):350-386.

[114] McHugh, M.L., (2012). “Interrater reliability: the kappa statistic”, Biochemia Medica, 22:276–282.S

TUSIAD OFFICIAL LETTER OF PROJECT

İstanbul, 21 Ekim 2016
Ref: ZAY/ya/16-1547

MİLLİ EĞİTİM BAKANLIĞINA

Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü

Bilgi toplumuna ve bilgi ekonomisine dönüşüm yolunda, özellikle **"STEM" (Science, Technology, Engineering, Mathematics/Fen, Teknoloji, Mühendislik, Matematik)** konusunda eğitim almış insan gücünün önemi her geçen gün artmaktadır.

Ülkemizde STEM konusundaki çalışmalara katkı sunmak üzere, kamuoyu nezdinde STEM konusunda farkındalığı ve STEM eğitiminin niteliğini arttırmaya yönelik çalışmalar yapmaktayız. Bu kapsamda; "STEM kiti ve öğretmen eğitimi" pilot projesi ile Ek'te arz edilen proje dokümanında belirtilen çerçevede, öğretmenlere yönelik eğitimler gerçekleştirmeyi arzu etmekteyiz.

Projemiz ile ilgili etkinliklerin gerçekleştirilmesi konusunda gerekli izinlerin verilmesi ve duyuruların yapılması hususunda bilgilerinizi ve gereğini arz ederim.

Zafer Ali YAVAN
Yönetim Kurulu Üyesi ve Genel Sekreter

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APPENDIX-B

MoNE OFFICIAL APPROVAL FOR THE PROJECT

T.C.
MİLLÎ EĞİTİM BAKANLIĞI
Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü

Sayı : 88013337-821.05-E.12192416 — 31.10.2016
Konu : TÜSİAD STEM Kiti ve Öğretmen
Eğitimi Projesi

……………..VALİLİĞİNE
(İl Milli Eğitim Müdürlüğü)

İlgi : Türk Sanayicileri ve İş Adamları Derneği (TÜSİAD)'nin 25/10/2016 tarihli ve 11887108 sayılı gelen yazısı.

Türk Sanayicileri ve İş Adamları Derneğinin; Bahçeşehir Üniversitesi STEM Merkezi iş birliğiyle İstanbul/Üsküdar, Hatay/Payas ilçelerinde ve İstanbul Darüşşafaka Eğitim Kurumlarında, ortaokul 5 ve 6. sınıf fen bilgisi veya matematik branşlarında görev yapan öğretmenlere yönelik, ekli şartname esasları doğrultusunda, **"TÜSİAD STEM Kiti ve Öğretmen Eğitimi Projesi"** düzenleme talebine ilişkin ilgi yazı ve ekleri incelenmiştir.

Söz konusu projenin; Türkiye Cumhuriyeti Anayasası, Milli Eğitim Temel Kanunu ile Türk Milli Eğitiminin genel amaçlarına uygun olarak, ilgili yasal düzenlemelerde belirtilen ilke, esas ve amaçlara aykırılık teşkil etmeyecek şekilde, denetimleri ilgili okul, il/ilçe milli eğitim müdürlükleri tarafından gerçekleştirilmek üzere, derslerin aksatılmaması kaydı ile gönüllülük esasına göre yapılması hususunda bilgilerinizi ve gereğini arz/rica ederim.

Bilal TIRNAKÇI
Bakan a.
Genel Müdür

Ek : İlgi yazı ve ekleri (8 sayfa)
Not: Etkinliğe, http://yegitek.meb.gov.tr/www/sosyal-etkinlikler/kategori/19 adresinden ulaşılabilir.
İrtibat: (0212) 249 1929-112

Dağıtım :

Gereği:
Hatay ve İstanbul İl Milli
Eğitim Müdürlüğü

Bilgi:
Temel Eğitim Genel Müdürlüğü
Din Öğretimi Genel Müdürlüğü
Özel Eğitim ve Rehberlik Hizmet. Gen. Müd.
Özel Öğretim Kurumları Genel Müdürlüğü
Türk Sanayicileri ve İş adamları Derneği
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Tel: (0 312) 296 94 27
Faks: (0 312)223 8736

Bu evrak güvenli elektronik imza ile imzalanmıştır. http://evraksorgu.meb.gov.tr adresinden 6da5-d5d9-37c9-8dfb-d341 kodu ile teyit edilebilir.

APPENDIX- C

TUSIAD STEM KIT CONTENT

Tablo 1. TÜSİADSTEM kitlerinin içerikleri veya gerekli malzemeler

Gerekli ana malzemeler
Günlük malzemeler (yumurta viyolü, tuvalet kağıdı, kağıt havlu rulosu, pet şişeler, oyun hamuru vs)
Güneş panelleri ve motorları
Arduino ve sensör seti
İzometrik kağıtlar üzerinde ya da freeware yazılımlar kullanan öğrenciler 3B yazıcıdan çıktılarını alabilecekleri tasarımları
K'nex seti

Günlük Malzemeler

Oyun hamuru

Opsiyon 1. Un, Su,Tuz, Yağ, Çeşitli renklerde gıda boyası (İsteğe bağlı)

Opsiyon 2. Tuvalet kağıdı, Tutkal, Su, Çeşitli renklerde gıda boyası (İsteğe bağlı)

Kapsanan kazanımlar;

6. sınıf Fen Bilimleri dersi 3. ünitesi: Maddenin Tanecikli Yapısı

- *Maddeyi Oluşturan Tanecikler*

6. sınıf Fen Bilimleri dersi 8. ünitesi: Dünyamız, Ay ve Yaşam Kaynağımız Güneş

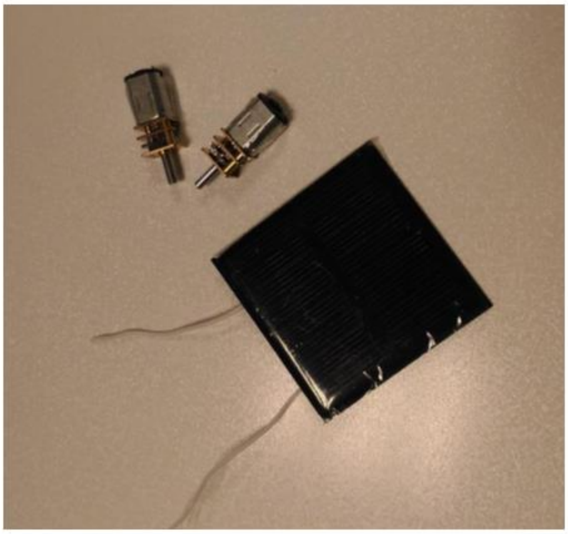
- *Dünya, Güneş ve Ay'ın Şekil ve Büyüklüklerinin Karşılaştırılması*
- *Dünyamızın Katman Modeli*

6. sınıf Matematik dersi 5. ünitesi: Geometrik Cisimler ve Hacim Ölçme

- *Hacim*
- *Prizmaların Hacmi*
- *Hacim Ölçü Birimleri*

Güneş Paneli ve Motorlar

6V gerilim sağlayan Güneş Pili ve 350 rpm devirli DC motor



Kapsanan kazanımlar;

5. sınıf Fen Bilimleri dersi 2. ünitesi: Kuvvetin Büyüklüğünün Ölçülmesi
- *Sürtünme Kuvveti*

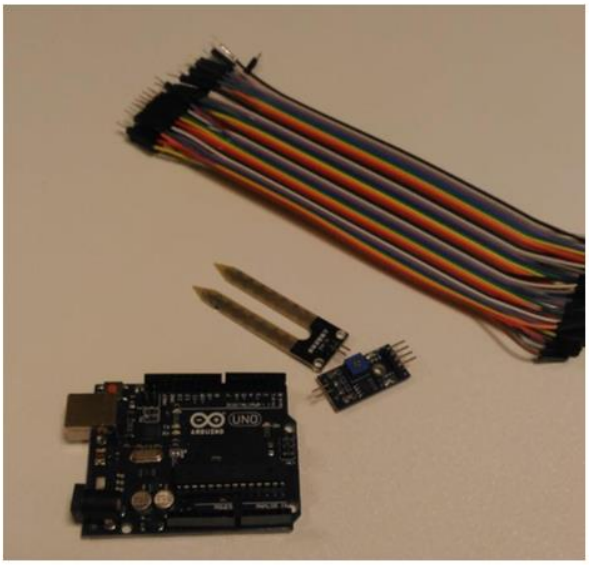
5. sınıf Fen Bilimleri dersi 4. ünitesi: Işığın ve Sesin Yayılması
- *Işığın Yayılması*

5. sınıf Fen Bilimleri dersi 6. ünitesi: Yaşamımızın Vazgeçilmezi: Elektrik
- *Devre Elemanları*

6. sınıf Fen Bilimleri dersi 2. ünitesi: Kuvvet ve Hareket
- *Sabit Süratli Hareket*

Prototipleme Kartı(Arduino) ve Sensörler

Programlanabilen ve gerçek zamanlı veri toplayan prototipleme kartı, sıcaklık sensörü, toprak nem sensörü, uzaklık sensörü, jumper kablolar



Kapsanan kazanımlar;

5. sınıf Fen Bilimleri dersi 6. ünitesi: Yaşamımızın Vazgeçilmezi: Elektrik
- *Devre Şemaları*

6. sınıf Fen Bilimleri dersi 7. Ünitesi: Elektriğin İleti
- *İletken ve Yalıtkan Maddeler*

5. sınıf Matematik dersi 2. ünitesi:
- *Araştırma Soruları Üretme,*
- *Veri Toplama, Düzenleme ve Gösterme*
- *Veri Analizi ve Yorumlama*

6. sınıf Matematik dersi 2. ünitesi: Oran
- *İki Nicelik Arasındaki İlişki*

İzometrik Kâğıt ve Çizim Gereçleri

İzometrik kâğıt, asetat kalemi, çizim kalemi, iletki, cetvel

Kapsanan kazanımlar;

5. sınıf Matematik dersi 5. ünitesi: Uzunluk ve Zaman Ölçme

- *Üçgen ve Dörtgenler Alan Ölçme*
- *Geometrik Cisimler*

6. sınıf Matematik dersi 5. ünitesi: Alan Ölçme

- *Paralelkenarın Alanı*
- *Üçgenin Alanı*
- *Alan Ölçme Birimleri*
- *Arazi Ölçme Birimleri*
- *Problem Çözme*
- *Problem Kurma*

K'nex Seti

K'nex seti; farklı uzunlukta plastik çubuklar, farklı açılarda plastik bağlantı parçaları, yardımcı birimler

Kapsanan kazanımlar;

6. sınıf Fen Bilimleri dersi 6. ünitesi: Madde ve Isı

- *Yenilenebilir Enerji Kaynakları*

6. sınıf Fen Bilimleri dersi 2. ünitesi: Kuvvet ve Hareket

- *Bileşke Kuvvet*

5. sınıf Matematik dersi 2. Ünitesi*:* Veri Analizi ve Yorumlama

- *Araştırma Soruları Üretme*
- *Veri Toplama*
- *Düzenleme ve Gösterme*

APPENDIX-D

RESEARCH CONSENT FORM

TÜSİAD

TÜSİADSTEM PROJESİ TÜSİAD
"STEM KİTİ VE UYGULAMA REHBERİ" PROJESİ İZİN FORMU

"Bilgi Temelli Hayatın Yenilikçi Çocukları İçin Bütünleşik Öğretmenlik"

"STEM Kiti ve Uygulama Rehberi" projesi, ülkemizin genç bireylerinin 21.yy becerilerini geliştirecek yenilikçi öğrenme ortamlarını tasarlamaları beklenen öğretmenlerimize yönelik bir mesleki gelişim programıdır. "STEM Kiti ve Uygulama Rehberi" projesi, TÜSİAD STEM Projesi'nin bir parçası olup, Bahçeşehir Üniversitesi BAUSTEM Merkezi Direktörü Doç. Dr. M. Sencer Çorlu tarafından Millî Eğitim Bakanlığı izin ve onayı ile yürütülecektir. Proje, 1 Ekim 2016 ile 31 Temmuz 2017 arasında 40 TÜSİAD**STEM** Lider Öğretmeni yetiştirerek, yaklaşık 3.600 ortaokul (5 ve 6. sınıflar seviyesinde) öğrenciye ulaşmayı hedeflemektedir.

Katılımcı öğretmenlerin her birinin TÜSİAD **STEM** Eğitimi liderleri olarak sorumluluk alarak aşağıdaki çalışmaları gerçekleştirmeleri beklenmektedir:

a) Güz ve bahar yarıyıllarında iki hafta sonu yüz yüze eğitimlere katılmak,
b) TÜSİAD **STEM** kiti ve uygulama rehberini teslim alıp, muhafaza edip, sınıf içerisinde yönergelere uygun şekilde uygulamak,
c) Portal platformunu aktif olarak kullanmak, çevrimiçi dersleri takip etmek, deneyimlerini portal üzerinden meslektaşları ile paylaşmak ve onların değerlendirmelerine açmak,
d) Ders planları hazırlamak, uygulamak, proje ekibinin vereceği dönütlere göre bu planları gözden geçirmek ve portalın projeye dâhil olan, olmayan herkesin erişimine açık olacak bölümünde toplumla paylaşmak,

Sayfa **1 / 3**

e) Ders planı uygulama fotoğraflarını, videolarını ve uygulama hakkındaki öz değerlendirmelerini portalda projeye dahil olacak öğretmenlere açık olacak bölüme yüklemek,
f) TÜSİAD **STEM** Fuarına yıl içerisinde oluşturduğu ürünlerle katılmak.

Veri analizi nitel ve nicel yöntemlerle incelenecek, araştırma kapsamında toplanacak veri Anayasa ve Millî Eğitim Temel Kanunu ile millî ve manevi değerlere aykırı, kişilik haklarını ihlal edici, cinsiyet, din ve ırk ayrımını körükleyici, belli bir politik yaklaşımı destekleyici, İnsan Hakları Evrensel Beyannamesine aykırı olamaz, Türk Ceza Kanunu'na göre suç olamaz, kişilik ve aile mahremiyetini ifşa edici sorular, ifadeler, resimler ve simgeler içeremez. Araştırma kapsamında toplanacak veri gizlilik içerisinde saklanacak ve kimliğinizi belli etmemesi için proje ekibi dışındaki kişilerle paylaşılmayacaktır.

Araştırmadan elde edilecek sonuçlar katılımcıların kimliklerine ilişkin bilgiler gizli tutulmak kaydıyla bilimsel ve raporlama amaçlı kullanılacaktır. Seminerler, sınıf uygulamaları ve bazı katılımcılarla yapılacak mülakatlar sırasında ses ve video kaydı alınacaktır.

Bu belge katılımcılara araştırmanın şartlarını bildirmek amacıyla sunulmaktadır. Katılımcılar herhangi bir olumsuzlukla karşılaşmadan çalışmanın tamamına ya da bir bölümüne katılmayı reddedebilir ya da herhangi bir zaman devam etmeme kararı verebilir. Ayrıca katılımcılar yürütücü tarafından çalışmadan çıkarılabilir.

Bu çalışmalara katılarak, size verilen eğitimlerin materyal, içerik ve yöntemini, proje yürütücüsünün yazılı izin olmadan sunum ya da herhangi bir başka ortamda paylaşmayacağınızı ve adil kullanım dışında alıntılamayacağınızı kabul etmektesiniz. Bu proje kapsamında, konusu 5846 sayılı Fikir ve Sanat Eserleri Kanunu ile 551 Sayılı Patent Haklarının Korunması Hakkında Kanun Hükmünde Kararname kapsamına giren tüm eser ve üretimlerinizin üzerindeki mali haklarını (çoğaltma, yayma, üçüncü kişilerin seçtikleri yer ve zamanda erişimlerini sağlayacak şekilde umuma iletilmesi, işleme haklarını) ve patent hakkını sonradan Türk Sanayici ve İşadamları Derneğine devredilmek üzere proje yürütücüsüne devretmeyi taahhüt etmektesiniz.

Herhangi bir sorunuz halinde aşağıdaki iletişim bilgileri verilen proje yürütücüsüne ulaşabilirsiniz.

Doç. Dr. M. Sencer Çorlu
BAUSTEM Direktörü ve TÜSİADSTEM "STEM Kiti ve Uygulama Rehberi"
Proje Yürütücüsü
e-posta: mehmetsencer.corlu@rc.bau.edu.tr
Tel: 0 212 381 5196

Adınız ve Soyadınız: ………………………….

İmza: ....

Tarih: ....

APPENDIX- E

STEM LESSON PLAN TEMPLATE

STEM Ders Planı Final

Tarih: **Ders:** **Konu:**

Öğretmen: **Sınıf:** **Süre:** .... dk

1. Hedef – Kazanımlar: (Hedef Kazanım Yazma Rehberi'ne danışınız).

Bilişsel Süreç Kazanımları:

1.1. Ana disipline ait kazanım:

1.2. Diğer STEM disiplinine ait kazanım:

1.3. Sosyal Ürün Kazanımları:

2. Kullanılan Materyaller:

3. Kaynaklar:

4. Ölçme-Değerlendirme:

1. Kullanılacak rubrikler:

2. Diğer ölçme yöntemleri:

Sayfa **1 / 2**

5. Bilgi Temelli Hayat Problemi (BTHP):

4.1. BTHP: (Açık uçlu, birden fazla çözümü olan, 21.yy hayatına ait, ürün-süreç birlikteliği).

4.2. Sınırlamalar: (Zaman, bütçe, kullanılacak materyaller, çevre dostu, işlevsellik veya kullanılan bilgi).

4.3. Meslekler ve Sorumluluklar:

6. Ders İçeriği: (Ders Planı Hazırlama Rehberine danışınız).

6.1. Derse Giriş: (İlk giriş etkinliği – hikayesi ardından BTHP sunumu; görev ve sorumluluk paylaşımları).

6.2. Deneme: (BTHP ve sınırlamalar üzerine tartışılması; *Bilgi Edinme* ve *Fikir Geliştirilme*nin başlaması).

6.3. Destekleme: (Gerekli temel kuramsal bilginin öğretmen tarafından verilmesi; anında değerlendirme yapılması, bu esnada *Ürün Geliştir*menin başlaması).

6.4. Derinleşme:(*Ürünü Test Et* aşamasına geçildiğinde bazı öğrenciler için ileri düzey araştırma ve/veya kuramsal bilginin verilmesi).

6.5. Değerlendirme: (Ürünlerin sunumu ve paylaşılması, değerlendirme rubriklerinin öğretmen tarafından neticelendirilmesi ya da notlu sınav-test yapılması).

APPENDIX- F

STEM LESSON PLAN RUBRIC

The STEM lesson plan rubric was utilized in this study to assess STEM lesson plans of participant teachers. The rubric which was developed within the scope of STEM: Integrated Teaching Project (ITP), was used with the permission or the principal investigator of ITP project, Assoc. Prof. Dr. M. Sencer Çorlu. The development process of this rubric included consideration of the framework of ITP project, revision of hundreds of STEM lesson plans and finally with some adjustments for end users: teachers.

This STEM lesson plan rubric includes seven different domains: target objectives, materials and resources, engagement, exploration, explanation, extension and lastly evaluation. Each domain has three categories; development needed, acceptable, target reached. The data collected as a result of using this tool is categorical. In this study, the authentic STEM lesson plans which were created by teachers participated in the teacher professional development project, were assessed by two raters with the STEM lesson plan rubric to explore the factors of technology and engineering integration further.

STEM Ders Planı Rubriği

Kategoriler	Geliştirilmesi gerekir (0- 3 puan)	Kabul Edilebilir (4 -7 puan)	Hedefe Ulaşılmış (8- 10 puan)
Hedef Kazanımlar	• MEB müfredatıyla ilişkisi zayıf. • Sadece merkezdeki branşa ait kazanımları içeriyor.	• Hedef Kazanım Yazma Rehberine uygun yazılmış. • MEB müfredatıyla ilişkili. • Hem merkezdeki branşa ait hem de en az bir diğer STEM disiplinine ait kazanımlara yer verilmiş.	• MEB müfredatıyla ilişkili. • Merkezdeki branşta müfredatın dışında da kazanım içeriyor. • Hem merkezdeki branşa ait hem de en az bir diğer STEM disiplinine ait kazanım içeriyor. • Diğer STEM disiplini olarak mühendislik ya da bilişim seçilmiş.
Kullanılan Materyaller-Kaynaklar	• Materyaller masraflı. • Sınırlı sayıda kaynağa danışılmış.	• Materyaller masraflı değil. • Ders kitapları yanında web siteleri de kullanılmış.	• Materyaller öğretmenin yaratıcılığını yansıtıyor. • Hem Türkçe hem de yabancı dillerde ders kitapları *veya* web siteleri kullanılmış.
Derse Giriş	• Kazanımlarla bağlantısı zayıf.	• Kazanımlarla bağlantısı yeterince güçlü değil. • İlgi çekici ve öğrencileri derse hazırlayacak bir etkinlik, hikâye ya da görsellik içeriyor.	• Kazanımlarla bağlantısı güçlü. • Öğrencileri derse hazırlayacak bir etkinlik, hikâye ya da görsellik içeriyor. • Öğrencilerin derse ön araştırma ve ön geliştirme yaparak hazırlanmaları sağlanmış.
Deneme	• Öğrencilerin sistematik bir yöntemle fikir geliştirmelerine imkân verilmemiş.	• Öğrenciler aralarında görev dağılımı yapmaları için desteklenmiş. • Öğrencilerin sistematik yöntemlerle fikir geliştirmeleri desteklenmiş.	• Öğrenciler aralarında görev dağılımı yapmaları için desteklenmiş. • Grup çalışması içerisinde farklı fikirleri sistematik şekilde geliştirmeleri için imkân verilmiş. Öğrencilerin geliştirdiği farklı fikirleri araştırma yaparak analiz etmeleri sağlanmış.
Destekleme	• Gerekli teorik bilgi sınıfta işlenmemiş.	• Gerekli teorik bilgi sınıfta öğretmen tarafından açıklanmış. • Sınavlarda çıkmış sorulardan örnekler verilmiş ya da çoktan seçmeli sorular sınıfta öğretmen tarafından çözülmüş.	• Gerekli teorik bilgi sınıfta öğretmen tarafından açıklanmış ve öğrencilerin sürece dahil olmaları için araştırma-geliştirme faaliyetleri ile ilgi kurulmuş. • Sınavlarda çıkmış sorulardan örnekler verilmiş ancak çoktan seçmeli sorularla yetinilmemiş, açık uçlu yorum gerektiren örnekler de verilmiş.
Derinleşme	• Merkezdeki branşa ait değil ya da yüzeysel şekilde tasarlanmış. • Sadece daha zor örnekler ile sınırlı kalmış.	• Merkezdeki branşa ait kazanımlarla bağlantısı yeterince güçlü. • Derinleşme üst düzey düşünme becerilerini destekleyecek örnekler ile sağlanmış.	• Merkezdeki branşa ait MEB kazanımlarının ötesinde üst düzey düşünme becerilerini destekleyecek örnekler ile öğrenciler araştırma ve geliştirmeye yönlendirilmiş. • Öğrencilerin araştırma ve geliştirme faaliyetlerini kendi sorularına yanıt arayacak şekilde genişletmeleri için fırsat verilmiş.
Değerlendirme	• Değerlendirme soru-cevap ya da quiz-test-sınav yöntemleri ile sınırlı kalmış.	• Hem bilgi hem de beceriler değerlendirilmiş. • Birden fazla değerlendirme yöntemi kullanılmış. • Hem ürün hem de süreç rubrikler ile değerlendirilmiş.	• Bilgi, beceri ve tutum ile ilgili değerlendirme yapılmış. • Öğretmen tarafından önceden açıklanan rubrikler, öğrencilerin katılımı ile tartışılmış ve geliştirilmiş. • Anında değerlendirme yapan sistemler kullanılmış. • Öğrencilerin süreç boyunca gelişimlerini ortaya koyabilecek yöntemler kullanılmış. • Öğrencilerin hem kendi ürünlerini hem de arkadaşlarının ürünlerini değerlendirebilmelerine imkân verilmiş.

APPENDIX- G

INTER-RATER RELIABILITY CALCULATIONS

Inter-rater reliability calculations were done based on the first and second raters' decisions regarding the rubric scores. The beforementioned rubric includes seven different domains; target objectives, materials and resources, engagement, exploration, explanation, extension and finally evaluation. For 32 STEM lesson plans every one of them was evaluated in seven different domains, a total of 224 scores was given.

Each domain has three categories; development needed, acceptable, target reached. The raters' agreement or disagreement were found out and the following table was generated.

Rater 1

Rater 2		Category 1	Category 2	Category 3	**Total**
	Category 1	1	4	0	**5**
	Category 2	3	166	3	**172**
	Category 3	0	5	42	**47**
	Total	**4**	**175**	**45**	**209**

κ indicates Cohen's kappa coefficient which is a measure of inter-rater agreement for categorical variables. P_o indicates the relative observed agreement among raters; P_e indicates the hypothetical probability of chance agreement.

$$\kappa = \frac{P_o - P_e}{1 - P_e} = 1 - \frac{1 - P_o}{1 - P_e}$$

For categories k, number of items N and n_{ki} the number of times rater i predicted category k:

$$P_e = \frac{1}{N^2} \sum_k n_{k1} n_{k2}$$

$$\sum P_e = P_{e1} + P_{e2} + P_{e3}$$

$$P_{e1} = \frac{5 \times 4}{224^2} = 0.0004$$

$$P_{e2} = \frac{172 \times 175}{224^2} = 0.5998$$

$$P_{e3} = \frac{47 \times 45}{224^2} = 0.0393$$

$$\Sigma P_e = 0.0004 + 0.5998 + 0.0393 = 0.6395$$

$$P_o = \frac{209}{224} = 0.9330$$

$$\kappa = \frac{0.9330 - 0.6395}{1 - 0.6395} = 0.8141$$

Cohen's kappa coefficient was found 0.81, this correlational coefficient demonstrated a strong agreement between the first and the second rater.

CURRICULUM VITAE

PERSONAL INFORMATION

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Foreign Languages	: English, German
E-mail	: helvaci.basak@gmail.com

EDUCATION

Degree	**Department**	**University**	**Date of Graduation**
Undergraduate	Science Education	Boğaziçi University	2014
High School	Science	Kocaeli Anadolu Öğretmen Lisesi	2007

WORK EXPERIENCE

Year	**Corporation/Institute**	**Enrollment**
2016 - Present	Bahçeşehir University – BAUSTEM Center	Research Associate
2017 - 2018	Enka Schools	IB Teacher
2015 - 2016	Boğazhisar Educational Institutions	Science Teacher

PUBLISHMENTS

Papers

1. Asik, G., Dogança Küçük, Z., Helvaci, B. and Corlu, M. S., (2017). “Integrated teaching project: A sustainable approach to teacher education”, Turkish Journal of Education, 6 (4), 200-215.

Conference Papers

1. Guven, B., Helvaci, B., Sarioglu Alpay, S. and Erdincler, A., (2015). “Analytical Analysis of Membrane Bioreactor Filtration of Household Wastewater by Euler, Heun and Runge-Kutta Methods”, 14th International Conference on Environmental Science and Technology (CEST), 3-5 September 2015, Rhodes.

2. Sıbıç, O., Helvaci, B. and Gül, M.D., (2016). “Diagnosing 7th grade students' cognitive structure about ‘Sensory Organs’”, 3rd International Eurasian Educational Research Congress (EJER), 31 May-3 June 2016, Mugla.

3. Helvaci, B., Corlu, M.S., Asik, G. and Dogança Küçük, Z. (2017). “STEM Ethics: Academic integrity and ethical concerns of teachers”, International Conference on Education in Mathematics, Science and Technology (ICEMST), 18-21 May 2017, Kusadasi.

4. Helvaci, B. (2017). “Eco-Teachers: Exploring Science and Mathematics Teachers' Tendencies to Undertake the Responsibility”, Institute of Environmental Sciences 3rd Annual Graduate Symposium, 5 June 2017, Istanbul.

5. Helvaci, B., Kamit, T., Adiguzel, T. and Corlu, M.S., (2018). “STEM Ethics”, Association for Teacher Education in Europe (ATEE) Winter Conference, 15-16 February 2018, Utrecht.

6. Helvaci, B., Toka, E. and Corlu, M.S., (2018).” Integrating Technology into Science and Math Classes: Approaches of STEM teachers”, 5th International Eurasian Educational Research Congress (EJER), 2-5 May 2018, Antalya.

7. Helvaci, B. and Unal, H., (2018). “TÜSİAD STEM Project: Exploring Technology and Engineering Integration in Mathematics and Science Classes”, International R&D, Innovation and Technology Management Congress (IRDITECH), 18 May 2018, Istanbul.

Books

1. Helvaci, B., Adiguzel, T., Karadeniz, S. (2017). STEM-FeTeMM Eğitiminin Hesaplamalı Düşünme Becerilerine Yaklasimi [Approach of STEM Education to Computational Thinking Skills]. In M. S. Çorlu, and E. Çallı (Eds). STEM Kuram ve Uygulamaları, Pusula, Istanbul.

2. Helvaci, B., (2017). 9. Sınıf Matematik Kümeler Ders Planı [9th Grade Mathematics Sets Lesson Plan]. In M. S. Çorlu, and E. Çallı (Eds). STEM Kuram ve Uygulamaları, Pusula, Istanbul.

3. Helvaci, B., (2017). 9. Sınıf Fizik Kuvvet ve Hareket Ders Planı [9th Grade Physics Force and Motion Lesson Plan]. In M. S. Çorlu, and E. Çallı (Eds). STEM Kuram ve Uygulamaları, Pusula, Istanbul.

4. Helvaci, B., (2017). 9. Sınıf Kimya Atom ve Periyodik Tablo Ders Planı [9th Grade Chemistry Atoms and the Periodic Table Lesson Plan]. In M. S. Çorlu, and E. Çallı (Eds). STEM Kuram ve Uygulamaları, Pusula, Istanbul.

AWARDS

1. Ministry of Education, Undergraduate Scholarship, 2007-2012.

2. Best Oral Presentation Award, Institute of Environmental Sciences 3rd Annual Graduate Symposium, Boğaziçi University, 5 June 2017, Istanbul.