DESIGN AND DEVELOPMENT OF E-TEXTILE SUPPORTED STEAM-BASED ACTIVITIES FOR THE PROFESSIONAL DEVELOPMENT OF MIDDLE SCHOOL SCIENCE TEACHERS

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ABSTRACT

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This study aims to explore the design principles for an e-textile-based STEAM training program, to examine the design, development, and usability issues of the STEAM activities, and to investigate the extent to which science teachers can apply STEAM training camp results in their courses. Design-based research was adopted for the study. After a few rounds of piloting with different samples, a STEAM module with seven hands-on activities was prepared and then applied to two independent groups of science teachers in two five-day-long camps: 20 and 19 teachers respectively. The primary data source, the interviews, was triangulated with observations, pre-and-post open-ended questions, survey data, and design artifacts. The qualitative inspection of the data resulted in five themes: experiences and opinions, perceived benefits, challenges, and transfer of camp learning and experiences. The study also provided design principles for STEAM activities.

The study findings showed that teachers mostly grappled with crafting a project design with the artistic merits and values, designing a fully functioning circuit, doing short-circuiting, drawing a design sketch, making the transition from sketch to project design, and sewing an electronic circuit into the fabric. Moreover, teachers are fairly convinced that they can transfer skills and practical experiences of the camp into the classroom. Also, teachers suggested that interdisciplinary collaboration must be established not only in the preparation of the activities but also in the implementation process. Additionally, engaging in STEAM activities is perceived to induce the development of affective skills, authentic learning skills, cognitive skills, collaborative learning skills, creativity skills, and skills in fundamental subjects. Finally, the study presented a set of design guidelines for a STEAM educational camp.

Keywords: STEAM Training Camp, STEAM activity, Electronic Textiles, Wearable Technologies, Science Teacher, Sewable Electronics.

ÖZ

ORTAOKUL FEN BİLGİSİ ÖĞRETMENLERİNİN MESLEKİ GELİŞİMİ İÇİN E-TEKSTİL DESTEKLİ STEAM ETKİNLİKLERİN TASARIMI VE GELİŞTİRİLMESİ

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Bu çalışma, e-tekstil tabanlı bir STEAM eğitim programının tasarım ilkelerini ortaya çıkarmayı, STEAM etkinliklerinin tasarım, geliştirme ve kullanılabilirlik konularını incelemeyi ve fen öğretmenlerinin STEAM kampı eğitiminin sonuçlarının derslerinde ne ölçüde uygulayabileceğini araştırmayı amaçlamaktadır.

Çalışmada tasarım temelli araştırma modeli kullanılmıştır. Farklı örneklemlerle yapılan birkaç pilot uygulamadan sonra, yedi etkinlikten oluşan bir STEAM modülü hazırlanmış ve beş günlük kampta bağımsız iki fen bilgisi öğretmen grubuna uygulanmıştır: sırasıyla 20 ve 19 öğretmen. Çalışma için tasarım tabanlı araştırma benimsenmiştir. Çalışmanın öncelikli veri kaynağı olan görüşmeler, gözlemler, ön-test ve son-test açık uçlu sorular, anket verileri ve tasarım eserleri ile desteklenmiştir. Çalışmada toplanan verilerin incelenmesi sonucunda beş tema ortaya çıkmıştır: deneyimler ve görüşler, algılanan faydalar, zorluklar ve kamp öğrenimi/deneyimlerinin aktarımı. Çalışma ayrıca STEAM etkinlikleri için tasarım ilkeleri de sunmuştur. Bulgular, öğretmenlerin çoğunlukla sanatsal özellik ve değerlere sahip bir proje tasarımı hazırlama, doğru çalışan bir devre tasarlama, kısa devre yapma, bir tasarım çizme, taslaktan proje tasarımına geçiş yapmak ve iletken ip kullanarak elektronik bir devreyi kumaşa dikmede zorluk yaşadığını göstermiştir. Ayrıca, öğretmenlerin kamp sırasında kazanmış olduğu etkinlikler ile ilgili bilgilerini ve pratik deneyimlerini sınıfa aktarabileceklerine karşı oldukça emin olduğu görülmüştür. Bunun yanında öğretmenler disiplinlerarası işbirliğinin sadece etkinliklerin hazırlanmasında değil aynı zamanda uygulama sürecinde de kurulması gerektiğini önermiştir. Ek olarak, STEAM etkinliklerine katılmanın duygusal ve bilişsel becerileri, otantik öğrenme ve işbirlikli öğrenme becerilerini, yaratıcılık ve temel konulardaki becerileri geliştirdiğine yönelik bir algı ortaya çıkmıştır. Son olarak, çalışma bir STEAM eğitim kampı için bir tasarım kılavuzu sunmuştur.

Anahtar Kelimeler: STEAM Eğitim Kampı, STEAM Etkinlik, Elektronik Tekstiller, Giyilebilir Teknolojiler, Fen Bilimleri Öğretmeni, Dikilebilir Elektronik.

To liberty, democracy, equal rights, and freedom of expression

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LIST OF ABBREVIATIONS

ABBREVIATIONS

STEM	: Science, Technology, Engineering, and Mathematics
STEAM	: Science, Technology, Engineering, Arts, and Mathematics
DIY	: Do It Yourself
STEAM ACTIVITIES	: E-Textile Supported Steam-Based Activities

CHAPTER 1

INTRODUCTION

> "Give ordinary people the right tools, and they will design and build the most extraordinary things."
>
> Neil Gershenfeld

This introduction section introduces the fundamental elements associated with the current research study. This section consists of the following four parts: background of the study, theoretical framework, statement of the problem, the purpose of the study, and research questions.

1.1 Background of the study

Together with the change from the industrial revolution to the information revolution (Toffler 1980, 1990), society has undergone significant changes in educational, social, and political areas than ever before. The radical shift was a necessary result of meeting the educational needs of the society and, specifically, in the educational perspective, fulfilling the learning needs, rates at which people learn, and the way people learn (Reigeluth, 2011). Information age brings about the development of new technologies, and those technologies switch with the old ones, which collectively created a technological revolution. Bostrom (2007) defined technological revolution as "a dramatic change brought about relatively quickly by the introduction of some new technology" (p. 129). In the past decade, the technological revolution has resulted in relatively increasing development in both science and technology and in turn, many transformations into every part of society. Therefore, 21st-century society has become more sophisticated, demanding, and competitive than ever before.

In his seminal and bestseller book, *A Whole New Mind*, Pink (2005) goes one step further beyond the information age and calls today's century as the conceptual age of the 21st century. In his word, Daniel Pink writes:

> We are moving from an economy and a society built on the logical, linear; ... Age to an economy and a society built on the inventive, empathic, big-picture capabilities of what's rising in its place, the Conceptual Age. (p. 2)

What Daniel Pink points out is the importance of cultivating creativity and strengthening innovation in what he calls the conceptual age of the 21st century. Therefore, he also noted that our society is transformed into the conceptual age focusing mainly on inventive, innovative, and creative skills from the information age, which focus on logical, sequential, and analytical skills.

The theoretical underpinnings of this study are akin to Pink's conceptual age vision that technology has built such an intensive partnership with science or vice versa that mastering either technological or science skills are not enough for individuals to continue their existence and careers in the community. Moreover, cross-disciplinary approaches that investigate and test systems as a whole rather than in isolation are necessary for the current society to comprehend and understand our planet better (Guy, 2013). For that reason, the educational community is now in an urgent need of specific and legitimate demand for students in the 21st century not only to be proficient in science subjects but also adapt to the rapidly changing social and technological developments. In other words, the acquisition of discipline-based knowledge would be incomplete unless the acquired knowledge and learned skills combine with interdisciplinary knowledge. Creativity, critical thinking, problem-solving, and communication are some of the essential skills students should possess to adapt to the 21st-century community.

1.1.1 STEM education

STEM education has emerged as a response to fulfilling the needs of 21st-century generation and equipping students with 21st-century skills and necessary interdisciplinary knowledge in today’s competitive world (Bybee, 2013; Moore et al., 2014). Similarly, Honey et al. (2014) stated that in today’s science- and technology-rich society, integrated STEM-related fields literacy becomes very important to train and educate productive, smart, and thoughtful citizens who can make sense of the world and produce democratic decisions. STEM is an acronym term used to describe communication across four disciplines, science, technology, engineering, and mathematics, in K-12 education groups, initiatives, programs, or practices (see Table 1.1). It is first introduced by the National Science Foundation (NSF) in 1990 with a different term. Then the name is changed to STEM. However, STEM, an educational approach, suffers from a lack of unity and agreement on the acronym’s meaning. For that reason, there seems to be no specific definition attributed to STEM education due to the diversity of the context in which it is being used (Bybee, 2013). Moore et al. (2014) identified STEM education as “an effort by educators to have students participate in engineering design as a means to develop technologies that require meaningful learning and an application of mathematics and/or science” (p. 4). In general, STEM education can be considered collective initiative and efforts made to improve the quality of science and mathematics education in the K-12 curriculum by leveraging and bringing the resources of four disciplines together in harmony under the same purpose or goal. Table 1.1 below shows the definitions of the four disciplines given by Honey et al. (2014, p. 14).

Table 1.1 The four STEM disciplines

Domain	Description
Science	"Science is the study of the natural world, including the laws of nature associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, or conventions associated with these disciplines. Science is both a body of knowledge that has been accumulated over time and a process—scientific inquiry—that generates new knowledge. Knowledge from science informs the engineering design process."
Technology	"Technology, while not a discipline in the strictest sense, comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves. Throughout history, humans have created technology to satisfy their wants and needs. Much of modern technology is a product of science and engineering, and technological tools are used in both fields."
Engineering	"Engineering is both a body of knowledge—about the design and creation of human-made products—and a process for solving problems. This process is designed under constraint. One constraint in engineering design is the laws of nature or science. Other constraints include time, money, available materials, ergonomics, environmental regulations, manufacture- ability, and reparability. Engineering utilizes concepts in science and mathematics as well as technological tools."
Mathematics	"Mathematics is the study of patterns and relationships among quantities, numbers, and space. Unlike in science, where empirical evidence is sought to warrant or overthrow claims, claims in mathematics are warranted through logical arguments based on foundational assumptions. The logical arguments themselves are part of mathematics along with the claims. As in science, knowledge in mathematics continues to grow, but unlike in science, knowledge in mathematics is not overturned, unless the foundational assumptions are transformed. Specific conceptual categories of K–12 mathematics includes numbers and arithmetic, algebra, functions, geometry, and statistics and probability. Mathematics is used in science, engineering, and technology."

The efforts to converge the STEM fields in the spotlight and include engineering academic standards in the science standards are not a new phenomenon. The beginning and development of the reforms underlying STEM education have their roots in the Sputnik era, which began in the 1950 and ended in 1976, with the development of new curriculum programs (Bybee, 2013). According to Bybee (2013), reformers of the Sputnik era have a shared vision of transforming the current content of topics and information, which is mostly based on textbooks, into a curriculum powered by inquiry-oriented ideas and movements and the conceptual fundamentals and research procedures of science and mathematics disciplines. The Sputnik era in this respect has had implications for the STEM era and resulted in significant impacts on educational reforms, which are mainly affected by the dominant political and social influences.

STEM education has been introduced as an interdisciplinary and integrated learning system initiated to provide educational solutions to the problems that involve multiple STEM disciplines. As mentioned above, integrated STEM education has a long history in literature, but over the past decade has gained great popularity and interest among researchers, educators, and even playmakers because of its potential impact on the quality of curricula and instruction.

Engineering is the core subject acting as a natural connector for integrating STEM disciplines. Therefore, a complete understanding of the nature of engineering is necessary for the effective integration of STEM content, especially by teachers (Moore et al., 2014). Engineering practice is often characterized by the concept of engineering design which is an “iterative process that begins with the identification of a problem and ends with a solution that takes into account the identified constraints and meets specifications for desired performance” (National Research Council [NRC] 2010, p. 6-7). Moore et al. (2014) argued that mathematics, science, and engineering have core intersection areas where science and mathematics play an integral role and have their roots in engineering. For that reason, integration of the subjects become meaningful as long as all these disciplines intersect meaningfully at common interests. That is, rather than traditionally blending STEM disciplines, Moore et al. (2014) called for curricula, in which the use of STEM contexts supports the learning of disciplinary content in meaningful ways.

1.1.2 STEM to STEAM

The most vital elements of our evolving and transforming society are complexity, interconnectivity, interaction, and communication. In such a complex, demanding, and competitive society, instead of teaching isolated disciplines based on simple reductionism, more holistic approaches like STEM education with the addition of Art (STEAM) are necessary to promote creativity (Guy, 2013). Creativity is a mental ability that can be cultivated and developed over time (Herrmann, 1991). There are different perspectives on what creativity is and what attributes it has. Some of the authors defined creativity as “the mental ability to conceptualize (imagine) new, unusual or unique ideas, to see the new connection between seemingly random or unrelated things” (Connor et al., 2015, p. 39) and “not a single entity but rather a collection of different thought processes” (Sousa & Pilecki, 2013, p. 50).

STEAM education is a newly growing framework aiming to remove barriers to traditional academic subjects with the integration of science, technology, engineering, arts, and mathematics into an integrated curriculum (Yakman, 2008). Sousa and Pilecki (2013) suggested that the addition of art to STEM education can be beneficial for students to learn the concepts related to the STEM subjects successfully. Besides, the convergence of STEAM fields can be highly valuable and crucial for students. For instance, it is capable of helping students nurture and develop creativity and enhance artistic competency, and also it has affordances to provide a collaborative learning and making space where students collaboratively work in peers and improve their skills in three domains of educational activities, including cognitive, affective, and motor skills.

Cognitive, physical, and emotional activities are some of the primary exercises which are necessary for human survival. To a certain extent, all these activities host art in some forms. Therefore, art is likely to be conceptualized as having different characteristics and features. For instance, John Dewey, one of the most influential authors, pointed out the aesthetic aspect of art. According to Dewey (1934), art "denotes a process of doing or making" (p. 48). The role of art in education is significant, and many authors advocate the important contributions of art on different aspects of students' learning. That is, art operates as both a driving force that allows the student to develop their imagination (Greene, 1995) and means that provides opportunities for a diversity of creative solutions and enabling students to learn about themselves, the group and the other cultures through interest-driven arts activities (Peppler, 2013b).

The role of the art in STEAM education is quite essential since art can provide useful and crucial cognitive competencies and capabilities. For instance, Sousa and Pilecki (2013) argued that these cognitive competencies could help students to meet the demands of the 21st century. Furthermore, Art has many capabilities to provide opportunities for multiple solutions (Peppler, 2013a) and refine our sensory system and cultivate our artistic abilities (Daugherty, 2013). In addition to that, art facilitates the development of many essential skills that are beneficial for learners in every aspect of their education. A large amount of the skills that are associated with arts are considered to be aligned with 21st-century skills. In one of the relevant books related to the incorporation of arts into STEM education, the authors identified arts as "a collection of skills and thought processes that transcend all areas of human engagement" and categorized skills that can be developed by arts as creativity, communication, collaboration, problem solving, critical thinking, self-direction, and initiative (Sousa and Pilecki 2013, p. 2). They further elaborated on the power of arts and stated that arts have the ability to help people to draw on curiosity, observe accurately, perceive the object in a different form, construct meaning and express one's observations accurately, work efficiently with others, think spatially, and perceive kinesthetically.

Moreover, in STEM education, the intended learning is based on skills associated with cognitive aspects. However, the cognitive dimension doesn't include other complementary skills attributed to art and related to creative aspects (Pink, 2005). Therefore, it is suggested that an educational program should address the acquisition of multiple skills related to art and STEM disciplines.

Many activities in the arts require teamwork, collaboration, communication, discussion, problem-solving, and performance. Social and collaborative dimensions are dominantly emphasized in art-related activities. Sousa and Pilecki (2013) argued that the addition and development of these aspects might be the main contribution of art in the STEM curriculum. Art-related activities are expected to be a creative and artistic form that stimulate students' brain's reward system and mental abilities like creativity.

1.1.3 Wearable technologies

Living in a technological era makes people's interaction with technology necessarily unavoidable. The ways people interact with technology have shifted over the past years, especially with the development and emergence of mobile, portable, and smart devices, tools, and ubiquitous computing technologies. In recent years, there has been a growing and dramatic growth of interest for use and development of different wearable technologies not only in the field of education but also in other areas like costumes, fitness, medical, entertainment, industrial, gaming, and lifestyle sectors. In literature, people have used wearable technology as an umbrella term under which they describe and discuss many different forms of body-mounted technological devices and tools that could be utilized in a wide range of disciplines and areas.

Wearable technologies can have different functions and purposes, depending on the context in which they function. For that reason, different forms of wearable technologies have been emerged and designed to possess many capabilities, which then can be used to serve for specific purpose and function. Some of the well-known and widely used ones are wearable computers, electronic textiles, smart clothing, and functional clothing. Different from other wearable technologies, the wearable computer is a part of a larger category, including a bunch of devices that may or may not compute. According to Barfield and Caudell (2001), a wearable computer is a "fully functional, self-powered, self-contained computer that is worn on the body…[and] provides access to information, and interaction with information, anywhere and at any time" (p. 6). As also clearly indicated in the definition, wearable technologies can incorporate many different sensors and electronic parts that can communicate with each other, other devices and the surrounding environment as well as gather, store, and process data, access information, and transfer information through analog and digital channels across different electronics.

Electronic textile or e-textile is a new dimension of wearable technologies that have gained prominence in recent years due to the shift in the ways we interact with technology. According to Peppler (2013b), e-textiles are novel and cross-disciplinary technologies that can augment participation and increase learning outcomes. A wide variety of electronic components find its place in e-textiles to develop the various aspect of learning in a range of disciplines and educational levels, including some novice and friendly-toolkits such as Lilypad Arduino and Adafruit Flora. These toolkits include a set of electronic parts including a microcontroller, switches, lights, speakers, conductive thread as well as broad and various sewable sensors that can be used to measure different types of information such as position, displacement, acceleration, force, volume, pitch, frequency, heart rate, temperature, neural activity, respiration rate, refraction, light wave frequency, brightness, luminance, and humidity (Barfield & Caudell, 2001; Peppler, 2013b).

1.1.4 Relationship of art with wearable technologies and STEAM education

Wearable technologies, art, and STEAM education are the fields that are closely connected in such a way that attributes of one part are essentially complementary to that of the other parts. Yakman (2008) clearly explained this linkage among all these fields by stating that "we now live in a world where; you can't understand Science without Technology, which couches most of its research and development in Engineering, which you can't create without an understanding of the Arts and Mathematics" (p. 3). As indicated in the quote, without conserving art, it can be challenging to fully and effectively harness the close connection of art with STEAM education and wearable technologies. Moreover, as an interdisciplinary approach, STEAM education is an intersection point where all the disciplines involved bring their unique practices and community values. In addition to that, wearable technologies should hold its place at the intersection of art and STEM disciplines because of providing unique opportunities to mediate transparency in STEAM education. To sum up, there is an obvious linkage between art, wearable technologies, and STEAM education.

1.2 Theoretical framework

The theoretical framework (or research paradigm) that guides the design and conduct of this research is based on the constructivism theory of learning (Piaget, 1972b) and Papert's constructionist extension (Papert, 1993). The root of the constructionism paradigm goes back to Seymour Papert (a student of Piaget), who developed a theory of constructionism based upon Piaget's constructivism. The theory of constructionism expanded on constructivism; therefore, the main philosophy underlying both theories are similar. Papert and Harel (1991) asserted that the main philosophy of constructionism is based on the "view of learning as building knowledge structures" (p. 1), just as the same in the constructivist paradigm. That is, both theories assert that students actively construct their knowledge by interacting with their environment. However, Papert's constructionism is different from Piaget's constructivism in terms of how knowledge is constructed (Ackermann, 2001). Focusing on the art aspect of learning such as *learning by making* or *making things in learning* is the featured hallmark of the constructionism paradigm (Papert & Harel, 1991). Different from constructivism, the ideas and beliefs of constructionism suggest that learners' active engagement in meaningful artifacts and social interaction and conversation with others around the making helps them facilitate the construction of their knowledge (Ackermann, 2001; Papert & Harel, 1991). Moreover, Papert stated that the constructionism paradigm helps us to understand how ideas are reshaped and reconstructed when expressed and subscribed to others' discussion and critique.

The assertion of the constructionism view concerning the conception of learning and the way learning takes place is aligned with the way individuals learn in STEAM education. In the theory of constructionism, learning is an active process involving the design and creation of meaningful learning objects/ artifacts, and interactions and discussions taken place in the meanwhile (Kafai 2006). The process of learning asserted to happen in the educational philosophy known as constructionism corresponds to the learning process in STEAM education. Therefore, as commonly applied in math and science contexts (Peppler, 2013a), the tenets of constructionism can help to explain how learning is constructed and mental models are built through the STEAM-powered activity processes. In this study, a space for making will be provided to learners where they as a group of two or three will be engaged in STEAM-powered activities. In those activities, technological and fabrication tools, materials, and apparatus given will enable learners to create and design their products or artifacts while at the same time interacting and discussing wither other learners. Getting involved in discussing with other learners and sharing their views about the products being created will help learners acquire intended knowledge and create their understandings. That's why the main conceptions and views underlying the constructionism will be the best suit to the dynamic, interactive, and meaningful learning process in STEAM education.

The role of making in the learning of STEAM fields is so significant that progressive educators and researchers start discussing where it stands out in education in terms of its potential pedagogical impacts on teaching and learning. What makes maker movement so popular across educators, researchers and even policymakers are its capability to enable learners interested in various type of making to bring their creative ideas, crafting skills, and imaginations into makerspace where they can design, built, and create different forms of innovative artifacts and fabrication with high and low-level technological tools such as circuits and programming tools. Making things is an act of do-it-yourself (or do-it-with-others), which is the hallmark of the maker movement. Seymour Papert, the founder of constructionism pedagogy, is credited by Martinez and Stager (2013) as "*the father of the maker movement*" (p. 17). According to Halverson and Sheridan (2014), this statement implies that the maker movement is underpinned by the theory of learning know as constructionism. The core center of maker movement involves embodied and production-based experiences, which are asserted by Papert's constructionism to play a fundamental role in people's learning processes (Harel & Papert, 1991). Maker movement has been used as an umbrella term covering a great number of making activities with different forms and formats. It is generally defined as *an innovative way to reimagine education* (Peppler & Bender, 2013) or *a new industrial revolution* (Anderson, 2012). More broadly, the maker movement is "the growing number of people who are engaged in the creative production of artifacts in their daily lives and who find physical and digital forums to share their processes and products with others" (Halverson & Sheridan, 2014, p. 496). It is proposed that maker movement is organized around three significant components: (1) *making* as a set of activities, (2) *makerspaces* as communities of practice, (3) *makers* as identities and also noted that examining and investigating each of these components in their natural settings require the utilization of particular approaches and research questions (Halverson & Sheridan, 2014).

Similarly, Hatch (2014), the writer of the compelling book called Maker Movement Manifesto, wrote that the makers' activities and mindsets in the maker movement has been shaped by nine principles, namely make, share, give, learn, tool up, play participate, support, and change. The common notion reflected and highlighted by the authors above is that the construction of physical objects is the distinguishing feature of the maker movement from the earlier revolutions. Makerspaces are part of maker movement that consists of a growing culture of hands-on activities involving designing, making, developing, creating, fabricating, and producing innovative forms of objects or productions from utilizing and exploiting various materials. As a result, the maker movement offers excellent potential to STEAM-powered activities for transforming the way people learn something by using the intersection of interdisciplinary approaches.

1.3 Statement of the problem

One of the significant educational challenges in 21st-century society is to fully equip individuals with a variety of knowledge from different domains so that they can adapt and survive in a rapidly changing and technologically evolving world. In this digital era, individuals must have multiple competencies in multiple subjects rather than just technical or intellectual skills. Moreover, in today's science and technology-rich society, problems being faced are more complex than ever before. Addressing such problems necessitates solutions from the convergence of multiple disciplines. STEM education came out as a contemporary approach serving to help students not only to acquire scientific and technological literacy but also to keep up with technological and scientific developments and innovations. However, there is a scarcity of research studies on how explicit integration can be insured and fostered across different disciplines so that learning, retention, achievement, and other valued outcomes can be facilitated and improved (Honey et al., 2014).

STEM education has many affordances, yet society's transformation from the information age to conceptual age calls for the addition of art pedagogies to STEM education because it could cultivate ingenious talents and boost creativity. In this respect, a large number of scholars asserted that integration of arts and STEM fields can be invaluable and bring many important contributions to the core STEM disciplines (Connor et al., 2015; Daugherty, 2013; Guy, 2013; Peppler, 2013a; Sousa & Pilecki, 2013; Yakman, 2008). Moreover, a study conducted by Park et al. (2016) showed that the majority of teachers agreed on the necessity of STEAM education and its perceived potential benefits and contributions towards cultivating convergent thinking, boosting creativity, and developing character building of students.

Although the goal in STEAM education is to provide students active learning environments where they can become active learners who become excited and curious and take control of their own learning, there have been a limited number of studies and evidence supporting the benefits and losses of integration of art and STEM (Daugherty, 2013), especially in wearable technology-based activities.

Wearable technology is still a new and emerging field. Therefore, a limited number of research in the use of wearable technologies in education unfold many important issues and challenges related to the design of such technologies (Bower & Sturman, 2015). Furthermore, most of the technologies have not been designed particularly for specific educational purposes, and their affordances have not been adequately explored and harnessed in both teaching and learning (Bower & Sturman, 2015), especially in STEAM-powered activities.

Recent research studies on e-textile or maker activities have proven that these hands-on practices are promising and useful tools to improve students' learning outcomes, nurture their interests, and broaden their participation in various subjects including science, technology, engineering, arts, and mathematics (Litts et al., 2017; Nugent et al., 2019; Peppler, 2013b; Peppler & Glosson, 2013; Searle et al., 2019; Searle et al., 2018; Tofel-Grehl et al., 2017). The instructional activities presented in these studies are led either by a formal teacher or by an informal teacher and carried out in either formal or informal settings.

However, these studies have predominantly used samples of students rather than teachers at the middle school level. Also, so far, little has been uncovered about the science teachers' practices or experiences with STEAM-powered activities and their perspectives upon the ways they should be designed to teach students electronics. Even though STEAM education holds a great interest within the scientific community and promises to converge different disciplines on the same subject, what roles teachers play in implementing STEAM-like activities and how those activities should be organized for the science teachers so that they can integrate into their science courses have not been well established in the literature.

Besides, the current study will provide a set of prescriptions and findings that can be used to provide insights to a certain extent into the understanding of "how STEAM education can be effectively implemented within the existing school system that highly focuses on test preparation" (Park et al., 2016, p. 1750). Moreover, the current study will offer important insights into designing, developing, and implementing wearable technology-supported STEAM-related activities.

1.4 Purpose of the study

The purpose of this study is to explore educational STEAM camp dynamics and prepare a set of STEAM activities for middle school science teachers. The study also investigates the design, development and usability challenges associated with STEAM activities and the effect of these activities on middle school teachers as well as students. Besides, the study aims to investigates the extent to which middle school science teachers can transfer their learning gains and experiences in designing and sewing STEAM activities to their lessons in school settings.

1.5 Research questions

Based on the purposes mentioned above, the current study addressed the following research questions.

1- What are the middle school teachers' perceived benefits of designing and sewing *e-textile supported STEAM-based activities*?

2- What are the middle school teachers' experiences and opinions about the implementation of *e-textile supported STEAM-based activities*?

3- To what extent middle school teachers can apply *e-textile supported STEAM-based training program* results in their courses?

4- What are the design, development, and usability challenges of *e-textile supported STEAM-based activities*?

5- What are the design principles for a *e-textile supported STEAM-based training program*?

1.6 Significance of the study

Our society has been continuously evolving as a result of the tremendous changes the world has undergone during the last twenty-five years. Society in 21st-century is therefore no longer the same as the one in 20st-century in terms of many aspects. All these changes have created unfamiliar and unique problems and challenges, along with the new opportunities, that could not be managed and solved by the approaches adopted in the 20th century. Therefore, we are in search of new methods and approaches that could meet the requirements of 21st century society. Guy (2013) clearly underlined this need in the following quote.

> The 21st century has opened a new basis for holistic non-linear design of complex systems, such as the Internet, air traffic management and nanotechnologies. Complexity, interconnectivity, interaction and communication are major attributes of our evolving society. But, more interestingly, we have started to understand that chaos theories may be more important than reductionism, to better understand and thrive on our planet. Systems need to be investigated and tested as wholes, which requires a cross-disciplinary approach and new conceptual principles and tools. Consequently, schools cannot continue to teach isolated disciplines based on simple reductionism. Science; Technology, Engineering, and Mathematics (STEM) should be integrated together with the Arts1 to promote creativity together with rationalization, and move to STEAM (with an "A" for Arts). (p. 1)

In recent years, two interconnected concepts, STEM and STEAM education, emerge as a response to the needs of 21st-century society by removing the boundaries across the different disciplines: science, technology, engineering, art, and mathematics. It has been widely argued that, without addition of art and design, the STEM approach would not successfully respond to the 21st century demands (Maeda, 2013; Yakman, 2008). The prevailing view of STEAM8 education rests heavily on its capability to foster innovation and creativity (Maeda, 2012) which is considered the precious asset in 21st century (Trilling & Fadel, 2009).

The development of new technological tools, specifically wearable e-textile technologies, have opened new rooms and valuable opportunities for the science teachers to apply STEAM-like approaches or practices in the classroom. It is widely believed that the STEAM activities can afford to provide engaging, exploring, creative, aesthetic, and customized learning experiences which are not available in traditional way of teaching and learning electronics in science lessons. However, so far little has been revealed regarding how in-service teachers should design and implement STEAM-powered activities in the existing educational curriculum and school settings, and where these activities mostly fit in science concepts. Moreover, all the information that has been accumulated about STEAM education is largely based on theoretical knowledge. In this regard, the current study is not only worth performing, but also its overall impact and potential benefits would be of great significance.

This study is significant in many aspects. First, the study provides teachers and researchers with a set of STEAM-powered activities that can be applied and implemented in the classroom to teach students electronics. Second, practicing and engaging in e-textile activities would help teachers firstly explore STEAM activities and then transfer their activity experiences and skills to classroom. Third, the study findings shed light on the problems and challenges that are likely to take place during the design and implementation of STEAM-like hands-on activities, which could be a useful guide for anyone, specifically teacher, researcher, school administrator, policymaker, and parents, who is interested in preparing and applying STEAM or similar activities. In addition to that, the findings from the study contribute to the body of knowledge about e-textiles and extend our understanding and knowledge of detailed design, development, and implementation process of STEAM-powered activities. Forth, using the design principles of a STEAM camp, the teachers can create STEAM-mediated learning environments where students can explore and learn by making things, interacting with artifacts, and communicating with the other leaners around them. Moreover, the design principles could guide curriculum developers and instructional designers during the integration of maker activities into the educational curriculum.

1.7 Definitions of terms

STEM: STEM stands for science, technology, engineering, and mathematics

STEAM: STEAM is an acronym for the fields of science, technology, engineering, arts, and mathematics.

STEAM Education: It is a teaching and learning approach that meaningfully integrates Science, Technology, Engineering, the Arts and Mathematics to engage learners in circumstances that call for inquiry, discussion, and problem-solving.

Wearable Technologies: Wearable technologies are "wearable digital devices that incorporate wireless connectivity for the purposes of seamlessly accessing, interacting with and exchanging contextually relevant information" (Bower & Sturman, 2015, p. 344).

Creativity: Creativity is defined as "the mental ability to conceptualize (imagine) new, unusual or unique ideas, to see the new connection between seemingly random or unrelated things" (Connor et al., 2015, p. 39).

Electronic Textiles (E-textiles): It is an approach combining electronics (i.e., microcontrollers, actuators, sensors) with fabrics and textiles using conductive thread.

CHAPTER 2

LITERATURE REVIEW

> "The most beautiful experience we can have is the mysterious. It is the fundamental emotion that stands at the cradle of true art and true science."
>
> Albert Einstein

This section contains a detailed information about the previous studies, including books, articles, proceedings, reports, and son on, which were reviewed and inspected within the context of this study. The information drawn from the literature sources are presented under the nine titles: STEM, STEAM, constructionism: a theoretical framework, teachers' perspectives and role in STEAM education, Arts, maker movement, wearable technologies / sewable electronics, technology supported STEAM practices and their potential impacts, in-service professional development, and the gap in the literature.

2.1 STEM (Science, Technology, Engineering, Mathematics)

STEM education, which is grounded in the tenets of constructivism and cognitive science, is an effort that emerges as a response to solve and deal with the complex problems and challenges that require the integration of concepts from multiple disciplines. Furthermore, STEM is an interdisciplinary and integrated education based on the "a holistic approach that links the disciplines, so the learning becomes connected, focused, meaningful, and relevant to learners" (Smith & Karr-Kidwell, 2000, p. 22). Integrated STEM education was defined as "an effort by educators to have students participate in engineering design as a means to develop technologies that require meaningful learning and an application of mathematics and/or science" (Moore et al., 2014, p. 4).

NRC (2009) published a report with the name of *Engineering in K-12 Education: Understanding the Status and Improving the Prospects.* The report argues that engineering is part of the real-world and therefore shares important commonalities with science, technology, and mathematics. Based on this argument, such an important question was asked: if these four disciplines could be integrated "why these subjects should be isolated in schools" (NRC 2009, pp. 164-165). Therefore, in K-12 education, the main goal underlying STEM education is to bring engineering standards and combine them with science standards in the science curriculum so that the meaningful connection can be accomplished between the learning content of mathematics and science. According to Moore et al. (2014), engineering works as a connector across the STEM disciplines. That is, science and mathematical ideas need engineering design to provide solutions to the problems.

Integrating engineering into science and mathematics provides a solution to remove the boundaries across the separate disciplines, but at the same time, raise a critical discussion that is worthy of mentioning. Many talks and critics predominantly revolve around the idea that STEM education is missing creative-related components that can be warranted by Arts. For instance, as also emphasized and echoed by Daugherty (2013), it is argued that STEM lacks a bunch of critical arts-driven skills that are crucial for fostering innovative ideas in a competitive workforce (White, 2011). Furthermore, by focusing on the necessity of transition from STEM to STEAM, Sousa and Pilecki (2013) noted that despite their subjective and objective way of looking at the world, science and arts are mutually complementary to one another. They further stated that suitable decisions are bound to be made when both views are in action.

Arts and STEM disciplines might have the opposite characteristics (Sousa & Pilecki, 2013). However, Arts is necessarily inherent in fields of STEM, especially science and engineering discipline. In 2006, Georgette Yakman proposed a STEAM framework, claiming that there is an inherent connection between arts and STEM disciplines. The STEAM framework presented was an attempt taken to integrate arts into STEM areas so that the boundaries, which are claimed to be more fluid than conventional learning paradigms (Root-Bernstein & Bernstein, 1999; Shlain, 1991), existing between arts and STEM disciplines can be broken down. In addition to Yekman, some STEAM efforts embraced the tenets of STEAM education and recognized the importance of creativity and arts in interdisciplinary approaches (Henriksen, 2014). For instance, as an essential strand to STEM education, arts are presented as a gateway to STEM learning (Piro, 2010). Moreover, in some research, it is identified that STEM cannot be treated without arts-driven creative and innovation acts and skills (Boy, 2012). The field of design, which involves both creative and technical skills, often draws from both arts and STEM disciplines. Therefore, the connection between Arts and STEM disciplines is not a one-way street, the connection is mutual, and the intersection of these fields often leads to new innovations, breakthroughs and a more holistic understanding of the world.

2.2 STEAM (Science, Technology, Engineering, Arts, Mathematics)

STEAM is an acronym of science, technology, engineering, art, and mathematics. STEAM education is an evolved version of STEM education. The only difference between STEAM and STEM education is the addition of the art discipline. Based on her extensive investigation regarding teaching and learning across the disciplines, Yakman (2008) come up with a STEAM Pyramid that can be used to examine the practice and study of the formal fields of science, technology, engineering, mathematics, and the arts (see Figure 2.1).

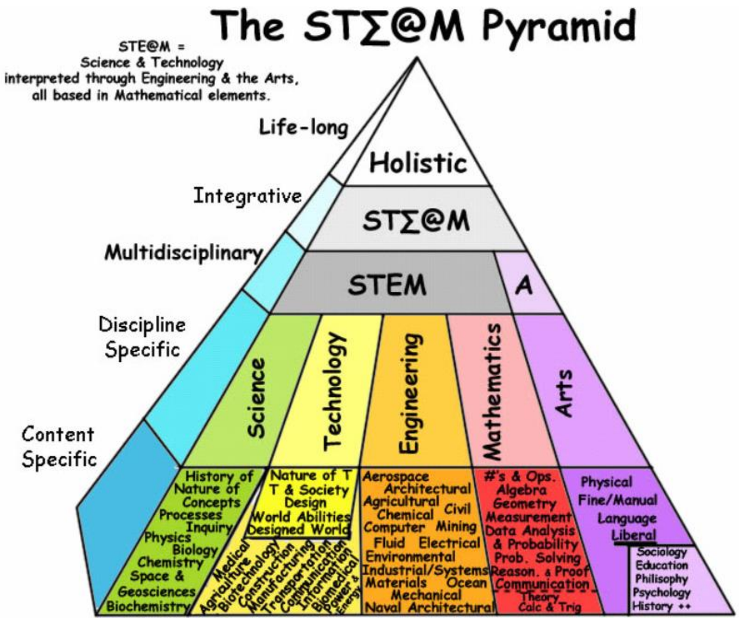

Figure 2.1. STEAM framework across the disciplines

As shown in Figure 2.1 above, Yakman (2008) classified educational divisions within each silo. Table 2.1 below shows the educational divisions included in each specific discipline described in STEAM framework.

Table 2.1 Educational divisions within each discipline

Disciplines	Educational divisions
Science	Biology, Biochemistry, Chemistry, Geosciences, Physics and Space Biotechnology & Biomedical
Technology	Agricultural, Construction, Communication, Information, Manufacturing, Medical, Power & Energy, Production and Transportation
Engineering	Aerospace, Agricultural, Architectural, Chemical, Civil, Computer, Electrical, Environmental, Fluid, Industrial & Systems, Materials, Mechanical, Naval and Ocean
Mathematics	Algebra, Calculus, Communication, Data Analysis & Probability, Geometry, Numbers & Operations, Problem Solving, Reason & Proof, Theory, and Trigonometry
Arts	Fine, Language & Liberal, Motor and Physical (including Education, History, Philosophy, Politics, Psychology, Sociology, Theology & more…)

Besides, the pyramid is horizontally divided into five parts, and each of the parts has a different name. Yakman stated that the most convenient and relevant level for primary and middle school education is the integrated level, where a group of people can work together and share their area of expertise and experiences on the same goal of helping students learn the content.

Depending on the STEAM framework, Yakman (2008) explained STEAM education as follows:

> We now live in a world where; you can't understand Science without Technology, which couches most of its research and development in Engineering, which you can't create without an understanding of the Arts and Mathematics. (p. 3)

According to Yakman's definition, each STEAM discipline is interconnected, and none of the disciplines can deliver desired results without incorporating some techniques from other disciplines.

2.3 Constructionism: A theoretical framework

Constructionism is a learning theory proposed by Papert (1987). The term "constructionism" was first coined by Seymour Papert. The first ideas that started to shape constructionism theory were back to late 1960 when Seymour Papert and his colleagues worked on the development of a programming language, named Logo, at MIT laboratory.

In his proposal submitted to National Science Foundation with the title of "Constructionism: A New Opportunity for Elementary Science Education" Seymour Papert introduced constructionism as follows:

> The word constructionism is a mnemonic for two aspects of the theory of science education underlying this project. From constructivist theories of psychology, we take a view of learning as a reconstruction rather than as a transmission of knowledge. Then we extend the idea of manipulative materials to the idea that learning is most effective when part of an activity the learner experiences as constructing is a meaningful product. (Papert, 1987, p. 2).

Papert's first proposal in the theory of "constructionism" was for science teacher education. In the proposal, he contended that students construct their representation of their knowledge when they deeply engage in making artifacts with technology. Then, Harel and Papert (1991) explained how the construction of learning in the constructionism view is linked to personal and social influences.

> Constructionism—the N word as opposed to the V word—shares constructivism's connotation of learning as "building knowledge structures" irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public

> entity, whether it's a sand castle on the beach or a theory of the universe. (p. 1)

Theoretical foundations of constructionism are substantially drawn on both constructivist and social theories of learning. Constructionism is the extended version of Jean Piaget's theories of constructivist learning (Piaget, 1972a), which is a theory of knowledge based on the premise that individuals construct knowledge and meaning from their experiences acquired through interactions with the surroundings in the world. Therefore, some similarities are common to a certain extent in both approaches. Despite its roots in Jean Piaget's theories of constructivist learning, constructionism is different in terms of the focus and emphasis placed on the factors that influence learning (Ackermann, 2001; Kafai, 2006; Papert & Harel, 1991). That is, Piaget's constructivist theories emphasized the critical role of individuals' experiences in actively constructing knowledge from their experiences. However, this view has been evolved into a different theoretical framework, called constructionism, underpinned by the premise that both individual and social factors play a crucial role in the construction of new knowledge (Papert, 1987). Moreover, in constructionism, what is essential is that people make their ideas instead of getting them through active engagement in the process of creating their personally meaningful objects as well as interaction and communication with others around them (Resnick, 1998).

The central tenet of constructionism is that the idea first develops inside the head and then an external representation of that idea is designed and created outside of the head (Harel & Papert, 1991; Kafai, 2006; Kafai & Resnick, 1996). Harel and Papert (1991) equated constructionism with the idea of "learning-by-making," which is an educational method where the construction of knowledge is achieved through the creation and making of things by using tools or technologies. Similarly, constructionism refers to "learning by constructing knowledge through the act of making something shareable" (Martinez & Stager, 2013, p. 21). While describing the idea of constructionism, Papert and Harel (1991) gave a particular example of art class in which students are working on soap sculptures. Student's engagement in creating sculptures, with his own words, “allowed time to think, to dream, to gaze, to get a new idea and try it and drop it or persist, time to talk, to see other people’s work and their reaction to yours…” (p. 1). In addition to that, Seymour Papert proposed eight big ideas behind the constructionist learning laboratory: “learning by doing”, “technology as building material”, “hard fun”, “learning to learn”, “taking time – the proper time for the job”, “you can’t get it right without getting it wrong”, “do not unto ourselves what we do unto our students”, and “digital world” (Martinez & Stager, 2013, p. 73). The idea of constructionism is therefore more applicable and suitable in design-based activities where individuals actively engage in creating personally meaningful products, objects, artifacts, or things.

2.4 Teachers’ perspectives and role in STEAM education

While integrating STEAM education into the educational curriculum, different from other stakeholders (e.g., policymakers, curriculum developers, instructional designers, etc.) teachers as the foremost practitioners relatively play a significant role in policy implementation, especially when it comes to the practice and application of STEAM-related activities in their courses. Therefore, teachers’ thoughts and perceptions related to a STEAM curriculum and its perceived impacts on students’ learning are of vital importance to foresee the possible implementation issues in STEAM-related activities. Several studies were conducted to examine and explore STEAM education and its implementation in schools by looking at different perspectives and dimensions. They focused on difficulties and challenges encountered in the STEAM classes, perceptions toward the practice of STEAM lessons, perceived benefits of STEAM education, and concerns regarding STEAM education.

In a survey study, a large sample of 729 elementary, middle, and high school teachers reported their perceptions regarding their practice of STEAM lessons, perceived benefits of STEAM education, and challenges they have encountered while implementing STEAM lessons in their courses (Park et al., 2016). Study results showed that STEAM education/lessons were most frequently used by elementary school teachers, particularly during science class in a substantial proportion. Although half of the teachers reported implementing one or two STEAM lessons per month, elementary school teachers were more than five times higher than middle and high school teachers in implementing five or six STEAM lessons per month. When it comes to using of STEAM lesson in school subjects, six out of ten teachers reported to apply STEAM education in science classes and science was selected a core subject by most of the elementary teachers (75%) than the middle (25%) and high school (49%) teachers. In addition to that, the challenges encountered by teachers while implementing STEAM education included a lack of administrative and financial support, scarcity of time for preparing STEAM lessons, increased workloads, and difficulties in using new media and experimental equipment.

Another study conducted by Lim and Oh (2015) reported the perceptions of teachers on STEAM Education and the reasons why they use it. According to teachers' responses, one of the reasons to apply STEAM education was to facilitate the development of cognitive and affective dimensions. Moreover, the majority of participants prefer to use STEAM education in science class. Regarding STEAM education, teachers saw technology as the most convenient subject and art as the most difficult one. According to teachers, development and improvement of STEAM education depends on progress in STEAM programs and sharing resources related to STEAM practices. Almost all of the teachers were aware of the positive contributions of STEAM education on science education. Differently, Cho and Park (2013) examined teachers' existing level of concerns regarding STEAM education. Study result indicated that teachers' concern levels on STEAM education were low. In addition to that, teachers applied trial and error strategy in their STEAM-related courses due to the insufficient knowledge of STEAM education, as well as lack of time for designing STEAM courses.

2.5 Arts

There is a widely accepted idea that the arts play an important role in students' learning (Peppler, 2013a). Peppler (2013a) considered arts learning within the perspective of making and called it new media arts. According to Peppler (2013a), Media art, different from traditional disciplines including visual art, music, dance, and theater, is the "art that makes use of electronic equipment, computation, and new communication technologies" in Do-It-Yourself (DIY) productions (p. 43). Despite the difference, Media art still has common concepts and terminology with a stream of traditional disciplines. Peppler described media arts as a "meta-medium" that includes a wide variety of artistic practices.

It is well known that arts as scientific tools bring many contributions to the disciplines. Arts, different from other disciplines, including science, technology, engineering, and mathematics, have distinctive characteristics. Sousa and Pilecki (2013) indicated how arts are different from other STEM fields in terms of relative characteristics. Accordingly, in terms of characteristics, while STEM fields are objective, logical, analytical, reproducible, and useful, the characteristics of arts are subjective, intuitive, sensual, unique, and frivolous, Arts is subjective, intuitive, sensual, unique, and frivolous.

In addition to contributing to other disciplines with distinctive features, arts training can also have effects on cognition. In a meeting where more than 300 educators, scientists, school administrators, and policymakers participated to share their thoughts experiences, and perspectives from cognitive-neuroscience research and to explore how creativity, cognition, and learning might be influenced by arts practicing and training, the arts were considered and discussed in terms of its impacts on some aspects of cognition (Hardiman et al., 2009). The results of studies reported in summit presentations indicated that art training is tightly correlated with improvements in cognition, attention, and learning. Moreover, from the perspectives of empirical classroom experience, it is suggested that when arts-based pedagogy is carefully structured, learners can be deeply engaged in subject matter and involved in learning. Researchers in the panel reported a set of scientific findings that affirm the benefits of arts training and the importance of integrating arts into schools and classrooms. One of the summit outcomes was that a better understanding of art is necessary for the successful integration of the arts across the curriculum.

2.6 Maker movement

Being up to date about the new trends in education is one of the important qualities of a good teacher. Teachers, who are known as the first practitioners of innovations, adapt and transfer the latest and cutting-edge technologies to classroom settings and exploit their affordances in teaching and learning processes. Ongoing discussions and recently published New Media Consortium's (NMC) and Innovative Pedagogy reports on emerging technologies that are presumed to have a significant impact on education in the time being and the next few years have ranked maker movement as being one of the intriguing and influential innovation in educational practice (Johnson et al., 2012; Sharples et al., 2013). In Innovative Pedagogy report, they put maker culture on top-tech innovation under the title of "learning by making" movement which is a movement that "encourages novel applications of technologies, and the exploration of intersections between traditionally separate domains and ways of work" (Sharples et al., 2013, p. 33).

Despite the newness of this phenomenon, the maker movement has been taken great attention and popularity due to its influences and potential pedagogical impacts on teaching, learning, and education during the last decade. According to Peppler and Bender (2013), the maker movement is being increasingly recognized to possess a lot of potentials to revolutionize *how and what people learn* in STEAM disciplines. Definitions attributed to the maker movement can be differentiated due to a wide range of contexts in which it is being implemented. However, the maker movement is "the growing number of people who are engaged in the creative production of artifacts in their daily lives and who find physical and digital forums to share their processes and products with others" (Halverson & Sheridan, 2014, p. 496). Do-it-yourself (DIY) activities are the hallmark of the maker movement, and almost every making activity can be considered as a DIY activity such as textile craft, computers, robotics, cooking, wood- crafts, electronics, digital fabrication, mechanical repair, creation, and so on (Peppler & Bender, 2013). The history of maker movement goes back to the Maker Fairies, public and annual event firstly established in 2006 by a biweekly magazine called "MAKE." Maker fairies are the big events dedicated to bring thousands of makers and a wide range of do-it-yourself projects together so that people can see, experience, contribute, participate, and be a part of these projects.

In literature, many authors have focused on important elements or components of the maker movement and tried to understand and describe them within the context of both formal and informal education in the maker movement. For example, in their seminal article, Halverson and Sheridan (2014) proposed three elements of maker movement for writing research questions and making design and policy decisions. As the elements of the maker movement, they considered making as a set of activities, makerspaces as communities of practice, and makers as identities, respectively. Each of the element was described as follows:

(1) making as a set of activities – making refers to a set of activities that can be designed with a variety of learning goals in mind. Making can happen in a variety of places that may be labeled "makerspaces" as well as in classrooms, museums, libraries, studios, homes, or garages. This approach is the closest to other constructivist- and constructionist-based design work that focuses on engaging participants in learning content and process. (pp. 501-502)

(2) makerspaces as communities of practice – Makerspaces are the communities of practice constructed in a physical place set aside for a group of people to use as a core part of their practice. While making activities are a part of the community, they do not fully constitute it. Our research suggests that communities of practice emerge around makerspaces as members co-participate in a range of activities, including taking walks, playing board

games, caring for resident pets, and attending Maker fairies and community events unrelated to making. (pp. 501-502)

(3) makers as identities – Makers describes the identities of participation that people take on within the maker movement. (pp. 501-502)

Similarly, in his book *Maker Movement Manifesto*, Hatch (2013) manifested nine elements of maker movement: make, share, give, learn, tool up, play, participate, support, and change. Hatch considers his manifesto as an initial sketch, which is open to further improvement, and therefore, he suggests that "in the spirit of making, I strongly suggest that you take this manifesto, make changes to it, and make it your own. That is the point of making" (p. 2). Each of these elements is described in Table 2.2 (Hatch, 2013, pp. 1-2).

Table 2.2 Nine principles of maker movement

Elements	Definition
Make	Making is fundamental to what it means to be human. We must make, create, and express ourselves to feel whole. There is something unique about making physical things. These things are like little pieces of us and seem to embody portions of our souls.
Share	Sharing what you have made and what you know about making with others is the method by which a maker's feeling of wholeness is achieved. You cannot make and not share.
Give	There are few things more selfless and satisfying than giving away something you have made. The act of making puts a small piece of you in the object. Giving that to someone else is like giving someone a small piece of yourself. Such things are often the most cherished items we possess.
Learn	You must learn to make. You must always seek to learn more about your making. You may become a journeyman or master craftsman, but you will still learn, want to learn, and push yourself to learn new techniques, materials, and processes. Building a lifelong learning path ensures a rich and rewarding making life and, importantly, enables one to share.
Tool Up	You must have access to the right tools for the project at hand. Invest in and develop local access to the tools you need to do the making you want to do. The tools of making have never been cheaper, easier to use, or more powerful.
Play	Be playful with what you are making, and you will be surprised, excited, and proud of what you discover.
Participate	Join the Maker Movement and reach out to those around you who are discovering the joy of making. Hold seminars, parties, events, maker days, fairs, expos, classes, and dinners with and for the other makers in your community.
Support	This is a movement, and it requires emotional, intellectual, financial, political, and institutional support. The best hope for improving the world is us, and we are responsible for making a better future.
Change	Embrace the change that will naturally occur as you go through your maker journey. Since making is fundamental to what it means to be human, you will become a more complete version of you as you make.

In literature, the term “maker movement” is treated as a composite term consisting of a range of structured DIY making activities from electronic-based to textile-based formats. Electronic textile is a part of maker movement using the electronic and computing together with textile materials that are sewn with conductive thread and combining knowledge from different areas of crafting, engineering, and computing (Kafai et al., 2014). E-textiles refer to “only one type of hybrid activity that combines the digital and material in authentic, aesthetic ways and can draw diverse groups of youth into identification with disciplines by connecting seemingly abstract computing and concrete, hands-on, do-it-yourself craft” (Kafai et al., 2014, p. 553). While nearly everything from the digital to physical (e.g., woodworking, cooking, repairing, sewing, etc.) is the part of “making”, computational tools are the most used and featured ones due to the fact that they are cheap and can be found everywhere (Frauenfelder, 2010; Gauntlett, 2011).

Teachers, educators or trainers are an important part of any makerspace. It is obvious that the teacher’s role as a facilitator in the makerspaces is different than the role adopted in a traditional teacher-centered classroom. Although a variety of roles can be attributed to the teachers in makerspaces, they are typically considered as facilitators or enablers who monitor, support, and tutor students while making things (Schön et al., 2014). According to Schön et al. (2014), there might be a shift in the expertise of the teacher and the student in maker settings. In other words, a teacher who is normally ascribed to be the most experienced person in the classroom could switch to being a facilitator when it comes to the maker settings.

2.7 Wearable technologies / sewable electronics

Wearable technology or device is not a recently emerged phenomenon. However, recent technological developments and innovations have enabled the design and development of a range of new wearable devices that have different functions depending on the purpose for which they are produced. In the context of the hands-on projects mixing electronics with fabric to suit the educational needs of the students, several terms have been coined to refer to wearable technologies such as wearable computers, wearable technology, electronic textile, smart clothing, and functional clothing. However, wearable technology is a well-known and frequently used umbrella term under which a wide variety of devices and technologies are covered. In the literature, different definitions have been attributed to the concept of wearable technology due to the differences in their usage in various settings. For instance, in a recently published new media consortium horizon report, wearable technology is defined as “computer-based devices that can be worn by users, taking the form of an accessory such as jewelry, eyewear, or even actual items of clothing such as shoes or a jacket” (Adams Becker et al., 2016, p. 16). In a different definition, Bower and Sturman (2015) called wearable technologies “wearable digital devices that incorporate wireless connectivity for the purposes of seamlessly accessing, interacting with and exchanging contextually relevant information” (p. 334).

A variety of wearable technologies are available with different capabilities such as Google Glass, Oculus Rift, Smartwatches, and e-textile. These wearable devices can be integrated with a person’s everyday life and movements and used to collect, store, and process information from the surroundings, check e-mail and perform other productive and useful tasks. Furthermore, according to the NMC horizon report that draws on data from professionals in the higher education field, wearable devices become effective technologies that enable a person to seamlessly and comfortable wear them and conveniently engage in everyday activities (Johnson et al., 2012).

E-textiles, also known as “smart textiles,” are fabrics that have been enhanced with electronic components, such as sensors, conductive threads, and microcontrollers. The design of e-textiles involves a combination of traditional textile design and electronic engineering. Additionally, e-textiles are emerging technologies as well as soft and fabric-based computers that make the devices truly wearable. In addition to providing art materials to fashion designers, textile designers, and artists, e-textiles can provide opportunities to remove the boundaries existing in the existing education fields. Lilypad Arduino construction kit is a wearable device that can be used to create and design soft and wearable computers. In a study conducted by Buechley and Eisenberg (2008), a group of people from different age groups were allowed to build their electronic fashion design by using the Lilypad Arduino. They organized six workshops, each with varying groups of age. At the end of each workshop, participants introduced and exhibited their wearables to their friends and family. Researchers examined motivational and affective issues regarding the participants' experiences in the workshops. Many students expressed that they were highly interested and engaged in the course. Furthermore, survey data indicated that five out of eight students who participated in the last workshop were quite willing and interested in attending future courses in electronics.

Different wearable construction kits could be used to build hands-on and wearable projects such as Lilypad (Buechley & Eisenberg, 2008), Flora (Adafruit, 2012), and EduWear (Katterfeldt et al., 2009), and MakerWear (Kazemitabaar et al., 2017). In literature, different terms, with similar meanings, have been used to draw a range of technologies used in hands-on activities that combine engineering, design, crafting, fashion, and programming. Some of the featured terms are wearable technologies, wearable electronics textiles (hereafter, e-textiles), and sewable electronics. However, different from e-textiles and sewable electronics, the term wearable technologies cover a large spectrum of electronic devices and tools used in the larger and broader areas. Throughout this study, we commonly stick to the terms e-textiles and sewable electronics which describe any electronic device or tool that can be sewn into clothing or other textiles like felt or fabric with conductive thread.

The e-textiles toolkit or the Lilypad Arduino kit, developed by Dr. Leah Buechley and her research group at MIT laboratory, contains a set of sewable electronics including a programmable microcontroller (the Lilypad Arduino), an assortment of sensors, light-emitting diodes (LEDs), and conductive thread (Buechley, 2006). Having a flexible ability to embed into textiles makes these sewable electronics functionally useful and appealing among the people from different disciplines to integrate science, engineering, crafting, and fashion design (Buechley & Eisenberg, 2008).

As an essential part of wearable computing, the e-textiles or sewable electronics enables to create soft and fabric-based computers with many functionalities that could be worn. An e-textile project that combines sewable electronics with design, fashion, sewing, and crafting is a part of a wearable computer. In this regard, in addition to sewable electronics, e-textile projects require a supply of sewing and crafting materials. The role of e-textile projects in education in terms of their potential impact on teaching and learning is quite important and promising. These hands-on projects could exist in a variety of forms and also be designed to meet different educational demands and needs in or out of school settings.

2.8 Relevant studies on e-textile activities

The past decade has witnessed a growing interest among researchers in the potential of wearable technologies in various fields and particularly in the effects of incorporating these technologies into educational contexts. As part of wearable technology, electronic textiles or sewable electronics hold great promise for exciting, intriguing, and promising interdisciplinary hands-on learning opportunities in and out-of-school spaces. Several studies have investigated the potential of e-textile (maker) activities in different educational contexts, and they generally use a sample of students mostly from middle school (Searle et al., 2019; Tofel-Grehl et al., 2017) than elementary school (Nugent et al., 2019) and rarely from high school (Litts et al., 2017; Searle et al., 2018). These studies have shown that e-textile or maker activities are useful learning devices to improve participants' learning outcomes, nurture their interests, and broaden their participation in various disciplines (Kazemitabaar et al., 2017; Litts et al., 2017; Nugent et al., 2019; Peppler, 2013b; Peppler & Glosson, 2013; Qiu et al., 2013; Richard & Kafai, 2015; Searle et al., 2019; Searle et al., 2018; Tofel-Grehl et al., 2017). While one group of these studies focus on underrepresented or 'at-risk' students (Somanath et al., 2016), others engage students, especially girls who interested in arts, fashion, and design (Erete et al., 2016; Peppler, 2013b). Besides, the activities in those studies are led by either a formal teacher or an informal teacher, like the researcher, and carried out in either formal or informal settings.

A recent qualitative study investigated the engagement of two non-dominant female students, both from middle school level, in e-textile projects, and the effect of this engagement on their perceptions towards STEM fields (Searle et al., 2019). In the study, a standards-aligned e-textiles curriculum was carried out in middle science classrooms where students, along with their teachers, engaged in hands-on science activities. The analysis of study data stemmed from the observations, and the interviews with students and teachers showed that the students actively involved in activities and developed a positive perception of science. In another recent study with a large sample of 1426 upper elementary students (808 treatment and 618 control), the researchers employed quasi-experimental research to examine the effect of wearable e-textile activities on students' knowledge gain in circuitry, programming, and engineering design and their STEM self-efficacy (Nugent et al., 2019). In the study, the trained formal and informal teachers implemented the WearTec curriculum intervention in 29 schools in- and out-of-school learning settings. The curriculum involved in and after-school activities along with sewable electronics such as Lilypad Arduino, the conductive thread, LED lights, sensors, motors, and switches. The result indicated that students in the treatment group significantly improved their knowledge in circuitry and programming, but not in engineering design. Also, the study resulted in development in STEM self-efficacy in favor of students in the treatment group. Similarly, Searle et al. (2018) investigated the debugging challenges faced by 16 high school freshmen students (7 boys, 9 girls, 13–15 years old) in open-ended e-textiles design and the strategies they generated to deal with those challenging parts. In an eight-week long workshop, students participated in designing and crafting a series of three e-textile projects using sewable electronics (Lilypad construction kit), crafting and textile materials. The instructor-led activities were made out of school space, and its participation was voluntary. After analyzing students' artifacts and the data from different sources like field notes, observations, and interviews, the study results revealed that the students commonly struggled with crafting with conductive thread and constructing a physical and functioning circuit (spatial circuitry).

Previous research examined the effects of the e-textile projects on 23 high school students (4 boys, 19 girls, 16–17 years old) understanding of making working circuits and the ability to read, design and remix codable circuits (Litts et al., 2017). The students engaged in designing a series of e-textiles activities within 15 sessions, each lasting about 90 min in an elective course during school hours. The study found an increase in students' understanding of circuitry and the ability to read and redesign codable circuits. High school students were engaged in other studies on e-textiles or sewable electronics. Kafai et al. (2014) investigated 35 high school students' (15 girls, 20 boys) experiences in making e-textiles activities and the way these experiences promoted technological transparency, integration of aesthetics, and participation of the marginalized group, the girls. The activities were instructed and implemented by the researchers through three workshops in out of school space, each lasting four to six weeks. After inspecting the data coming from observations, students' projects, daily field notes, and interviews, the study showed that working with e-textiles makes technology more transparent, integrates aesthetics in learning, and help female students participate in computing.

Using quasi-experimental research, Tofel-Grehl et al. (2017) explored the effects of e-textiles projects on 8th-grade students' (n=155) learning outcomes and motivation for the STEM areas in eight science classes. While the four classes took the e-textiles unit, and the other four took the traditional circuitry unit. The activities were designed and implemented by the researchers and the teacher who was the lecturer in these eight science courses. Findings showed that students in both units acquired significant learning gains but did not differentiate. However, students in the e-textile unit demonstrated a significant positive attitude towards science subjects than those in traditional circuitry unit.

In Turkish context, there is relatively few research on the use of e-textiles for educational purposes. In one of the studies, using e-textiles, seven middle school students have developed a bicycle jacket that can give a turning signal to ensure the safety of bicycle riders (Parlak & Alper, 2022). According to the study results, students found the coding stage to be the most enjoyable and the sewing stage to be the most challenging. The study also reported that students had a better understanding of coding and project development stages. In another study, the authors conducted a nature and science camp for twenty-nine gifted students to examine how STEM-based educational camp can enrich the learning in terms of environment, content, process, and product (Okulu et al., 2022). In one of the activities in the camp, students used e-textiles to develop their project. They found that nature and science camp supported STEM education of gifted students on the basis of learning environment, content, process and product. Besides, in a recent study, Kara and Cagiltay (2023) designed and developed four e-textiles supported interactive educational games to support executive function skills of preschool children. Apart from reporting the characteristics, benefits, and drawbacks of e-textiles, they also found these games perceived to be useful by teachers to promote students' active participation and motivation.

2.9 Technology supported STEAM practices and their potential impacts

STEAM activities can have a variety of positive effects on individuals who participate in them. In a previous study conducted by Başaran and Bay (2022), three teachers first took a STEAM training module to learn how to conduct STEAM education in their classrooms. After that, they used their training learning and experiences to carry out hands-on STEAM activities in their classes following their two and a half months training. According to the study, students that engaged in STEAM activity practices under the teachers' assistance improved social and cognitive skills related to social product, teamwork, presentation, and engineering. Besides, a review study showed that teachers' confidence in conducting STEAM education increased because of teacher professional development courses (Kang, 2019). Similarly, teachers who engaged in learning STEAM practices gained confidence and increased knowledge in STEAM integration (An, 2020). The importance of developing teachers' professional development through STEAM educational practices is highlighted in other studies as well. For instance, it was shown that STEAM educational practices have a positive impact on teacher's professional development, and teachers with the knowledge of STEAM educational practices created more impact on students' competencies (Monkeviciene et al., 2020).

Engineering design process (EDP) is inherent in STEAM activities that involve the design of a product or tool. A recent study combined EDP-based STEAM activities with storytelling in quasi-experimental design to observe its effect on early childhood students (Erol et al., 2022). The study reported that activities helped students develop problem solving and creativity skills. In addition, a literature review study on the use of STEAM education in mathematics learning revealed that STEAM has a significant impact on problem solving and creativity, but its influence on collaborative and communication skills remains limited (Pahmi et al., 2022). The study also found that project-based learning is the most practical method to use in STEAM educational practices. In addition to that, some studies reported that STEAM-based courses promoted improvement in student's self-efficacy, learning performance (Hwang et al., 2018), and self-directed learning abilities (Lee, 2021).

Although STEAM education emphasizes the use of interdisciplinary knowledge and skills, some disciplines may have a greater use in STEAM-based practices than others. For example, a prior study found that STEAM activities relied heavily on basic science process skills and the engineering design process (Khamhaengpol et al., 2021).

While STEM emphasizes the development and integration of multidisciplinary skills, STEAM additionally emphasizes the importance of the arts in the development of multidisciplinary skills. Therefore, STEAM-based practices are anticipated to be successful in cultivating aesthetics. In a recent study, it was found that project-based learning that included STEAM activities promoted development in students' creative recognition (Lu et al., 2022).

Creativity has become an essential asset to people of the 21st century to address multifaced problems that could be solved by the convergence of multiple disciplines. It is not an attribute that can be easily defined. That is, Boden (1996) explained creativity as "a puzzle, a paradox, some say a mystery" (p. 75). That's why, as pointed out by Boden, the person who demonstrates creative acts do not know utterly what constitutes creativity and which factors are triggering those actions. Tardif and Sternberg (1988) noted that a significant portion of research related to creativity is formed to discern creativity in its nature and around related surroundings such as processes, persons, and products because dissecting creativity could be quite beneficial. Yet, it is possible to discern creative actions from ordinary actions. According to Bailin (1994), the source of creativity becomes a universal mystery, but still, some forms of shared ideas are formed regarding its nature. Those beliefs are as follows:

- Originality is the main predictor of creativity
- Ascertaining the value of a creative product is not possible, just because of unavailable standards and instruments that can be used to assess new creations
- Creativity is beyond the product. It is the manifestation of a novel and innovative form of idea and thinking which do not correspond to previously established norms
- Creative insight is restricted by existing conceptual frameworks and schema of knowledge
- Creativity is transcendent beyond the usual limits

Lewis (2005) categorized people within the domain and across domains in terms of creativeness. Domains refer to art, music, and electronics. According to Lewis, within a specific domain, people are naturally creative. However, when it comes to across domains, some standard abilities and characteristics are shared by people, including metaphorical and flexible thinking, awareness of the ethical issues in the fields, and eagerness to grasp intellectual skills.

Creativity is considered as a mental ability that could be possessed not only by artists but also by anyone in the society (Connor et al., 2015) and as an attribute that you can develop and cultivate with practice or as you experience the world (Herrmann, 1991). Differently, Connor et al. (2015) offered a solid definition of creativity, which is "the mental ability to conceptualize (imagine) new, unusual or unique ideas, to see the new connection between seemingly random or unrelated things" (p. 39). In addition to that, according to Lewis (2005), a growing consensus has been established around the notion of creativity, which suggests that creativity is a composite concept surrounded and influenced not only by individual traits but also societal and environmental factors. Additionally, a view offered by Csikszentmihalyi (1988) proposed that attributing creativity to an individual alone product would be mistaken. Instead, creativity is a product on which many factors have contributions including cultural domain and embedded social system. For example, art is considered as the source of provoking and stimulating creativity, especially in an interdisciplinary educational approach known as STEAM. The linkage between art and science has long been recognized (Root-Bernstein & Bernstein, 1999; Shlain, 1991).

2.10 In-service professional development

School administrators and teachers need to develop and improve professional skills and teaching effectiveness to deal with and meet the demands of the school-based curriculum (Craft, 1996). There is an acceptance notion that teacher development is mostly connected with and dependent on educational change (Fullan & Hargreaves, 1992). Therefore, while initiating and implementing a curriculum change, professional development programs play a vital and crucial role in the process of performing a change in teachers' attitudes, beliefs, classroom practices, and learning outcomes of students (Guskey, 2002). As a part of the professional development program, an in-service teacher training program is essential and highly crucial for facilitating the development of curriculum change and improving a body of professional knowledge (Ha et al., 2004). In a study investigating how teachers perceived in-service teacher training in terms of supporting curriculum change in physical education, teachers emphasized in-service training as a necessary means to help them apply a physical education program in school (Ha et al., 2004).

Teacher's quality plays a crucial element in the production of the desired learning outcome in middle education. In-service teachers' training program is one of the strategies used to enhance teacher quality in education. The purpose of in-service teachers' training programs is to improve teachers' competencies to facilitate and remediate students' learning. Professional training and development programs are part of teachers' training programs aiming to "alter the professional practices, beliefs, and understanding of school persons toward an articulated end" (Griffin, 1983, p. 2). Similarly, Guskey (2002) defined professional development programs as systematic efforts invested in engendering change in teachers' attitudes, beliefs, and classroom practices, and students' learning outcomes.

As part of their challenging professions, society calls for teachers to expand their knowledge about how to use cutting edge technologies in their teaching. According to Jung (2005), effective and efficient use of modern technologies is contingent upon teachers' awareness of those technologies' potentials as well as how to apply them in suitable settings with adequate support and training. Aligning knowledge and skills with up-to-date technologies can help in-service teachers deal with a range of classroom and school challenges (Cheng, 2016). As also pointed out by Kafai et al. (2014), the integration, reception, and adoption of new technologies like e-textile into education would be a challenging and time-consuming process just like the ones faced previously. However, the use of technology or tool by itself still would not be a solution that has been sought out for a long time. Instead, as argued by Cuban (2013), students' and teachers' development of alternative views can play a crucial role in the successful adoption of new technology. In this regard, maintaining the transfer of in-service teachers' knowledge and competencies related STEAM activities become quite essential to transfer application of what they have learned in training into their classrooms.

Transfer of training is defined as "an active process of adapting the learned competencies for use in the work situation" (Snoek & Volman, 2014, p. 92). In one of the matched-comparison design studies, research results showed that in-service teacher training created an improvement in elementary school students' reading and mathematics scores (Angrist & Lavy, 2001). In another study, Ha et al. (2004) examined teachers' perceptions towards the effectiveness of an in-service teacher training program provided to them by the Chinese University of Hong Kong and receptivity to curriculum change in physical education. The program was perceived to be useful to bring different stakeholders together, such as teachers, educational experts, and government curriculum officers.

Lee and Shin (2014) examined difficulties elementary school teachers encountered in their STEAM classes. After distributing open-ended questionnaires to elementary school teachers regarding their experiences of problems in class, they had an interview with a highly experienced in-service elementary school teacher to find out possible solutions to the problems identified in questionnaires. The teachers pointed out the importance of knowledge and experience gained from participation in the STEAM training in the development of solutions to the identified problems. Despite the vital role of teachers in students' learning, they are viewed as coaches, guides, and prodders in e-textile maker activities (Kafai et al., 2014).

As highlighted above, in-service teacher training activities or programs hold great promise for teachers to meet new instructional technologies and interdisciplinary methods and then integrate them into their courses. However, not all teachers have the same opportunity to access and engage in these training activities and introduce them into classroom, especially if they do their teaching profession in rural areas. In this respect, an in-service teacher training program that specifically targets teachers from schools in low socioeconomic regions can help middle school science teachers integrate STEAM activities into their classroom by utilizing and leveraging the pedagogical affordances of the wearable e-textile technologies.

2.11 The gap in the literature

The rapid growth and advances in technology and dissemination of knowledge have forced people to develop different types of skill sets that are applicable in a rapidly advancing world. Creativity, design, and engineering have come to at the forefront of educational considerations and national discussions. Many of the emerging tools, materials, practices, and products have been placed at the intersection of the arts and the STEM disciplines to develop creative, design, and engineering skills.

In literature, six driving forces were described to frame the maker movement including the do-it-yourself (DIY) movement, focus on STEM and STEAM education, information access and information abundance, affordable maker technologies, crowdsourcing, and participatory culture, open-source resources (Gerstein, 2015).

Up to now, several studies examined the pedagogical impact of STEAM education on learning outcomes by using electronics, e-textile technologies, and tools. For example, Peppler and Glosson (2013) investigated how youth develop an understanding of electrical circuits utilizing e-textiles toolkit and materials. Similarly, Magloire and Aly (2013) examined how students learn the concepts of circuits and electronics through crafts-based hands-on activities. However, most of the studies, reports, and papers provided theoretical information about STEAM-powered activities and e-textile design (Peppler, 2013b).

Makerspaces are an essential part of maker movement where learners engage in doing-it-yourself and hands-on activities, including arts, crafts, and science by using digital and e-textile materials. While some studies applied do-it-yourself and craft activities to encourage students' creativity, expressiveness, and playfulness (Seehra et al., 2015), other studies examined high school students' experiences in making electronic textile designs to find out the role of aesthetic in learning, the extent to which these maker activities promoted transparency of technology and influenced gender's perspectives toward participation in computing and engineering (Kafai et al., 2014). In another study, Kafai et al. (2014) applied a curriculum module in which they examine the use of electronic textiles through the Lilypad Arduino (e.g., design of circuits, program code) by high school students in computer science class.

In the literature, most of the studies provided theoretical information about the transition from STEM to STEAM education and integration of Arts pedagogies into STEM fields (Bequette & Bequette, 2012; Connor et al., 2015; Daugherty, 2013; Guy, 2013; Henriksen, 2014; Rolling, 2016; Sochacka et al., 2016; Watson & Watson, 2013; Wynn & Harris, 2012; Yakman, 2008). There are some research-based efforts made to implement STEAM practices into school settings, but the results of those studies were stemmed from documenting teachers' experiences of using STEAM practices in the classroom in terms of five indicators of STEAM practices: relevancy, student choice, technology integration, problem-based, and authentic assessment (Quigley & Herro, 2016). Findings reported by Quigley and Herro (2016) revealed that it took time for teachers to enact and implement STEAM-based practices in the classroom. The study further showed that teachers faced the challenge of accessing, experiencing, and expertizing the new technologies within their STEAM practices. There are, of course, other challenges accompanying the STEAM-based practices in the lesson, such as the teachers' difficulty of maintaining the integration of arts and academic integrity at the same time (Barber, 2015).

According to the relevant literature, even though there is a growing interest and popularity in the use of STEAM-powered activities in both formal and informal settings around the world, what is known about STEAM-powered activities up to this point is based primarily on theoretical information, ideas, thoughts, claims, and reports. The perceived potential pedagogical impacts of STEAM-powered activities on teaching, learning, and education seem to be appealing and promising in the realm of education. However, to ascertain the role, value, and benefits of STEAM-based activities, research-based studies are needed to thoroughly explore and document the process of integrating these activities into the school environment. Despite this fact, so far quite a few attempts have been undertaken to implement wearable technology-supported STEAM activities into the school. Unfortunately, their areas of investigation were limited to students' experiences of using hands-on activities in the classroom.

Furthermore, most people who are interested in STEAM education have focused almost entirely on examining the process of students' experiences and involvement in STEAM activities. Since teachers are the first practitioners who play a vital role in the adoption of new technologies in the classroom, their roles and contributions to what students learn in STEAM activities have been ignored. That's why, before students, it becomes urgent for teachers to get experience in wearable technology-based STEAM activities and then apply what they have learned into practice with students in the classroom. Consequently, there is a clear gap in the literature regarding how wearable technology-supported STEAM activities should be designed and developed so that teachers can effectively integrate and implement these activities in their school curriculum and turn within the existing educational system.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter describes the overall research design and methods employed in this study. The research methodology is presented and described under the following sections: research questions, research design of the study, materials and tools, the implementation of the study, researcher's role, the design thinking process, data collection, data collection process, data analysis techniques, and validation of the study.

3.1 Research questions

The primary purpose of this study is to design and develop STEAM activities at the intersection of art, crafting, and design for middle school teachers. The study also examines the effectiveness, strengths, and weaknesses of blended electronic and e-textile design to explore STEAM subjects within the context of maker projects. The following research questions are addressed in this study:

1- What are the middle school teachers' perceived benefits of designing and sewing *e-textile supported STEAM-based activities*?
2- What are the middle school teachers' experiences and opinions about the implementation of *e-textile supported STEAM-based activities*?
3- To what extent middle school teachers can apply *e-textile supported STEAM-based training program* results in their courses?
4- What are the design, development, and usability challenges of *e-textile supported STEAM-based activities*?
5- What are the design principles for a *e-textile supported STEAM-based training program*?

3.2 The research design of the study

This study used design-based research (DBR) to design, develop and use blended electronic and e-textile technologies in STEAM subjects for middle school students (Wang & Hannafin, 2005). There are some well-known and widely accepted DBR definitions proposed by prominent scholars. For instance, according to Richey and Klein (2007), design and development research is "the systematic study of design, development and evaluation processes with the aim of establishing an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models that govern their development" (p. 1). Similarly, it is defined as "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories" (Wang & Hannafin, 2005, p. 6). These two perspectives describe that DBR is a systematic process composed of several consecutive phases used to create a specific tool or model in collaboration with the researchers and practitioners in real-world settings.

There is a conceptual confusion related to the design and developmental research (DDR) paradigm. It is quite possible to come across many kinds of research approaches that are described under different terms and labels. For example, there are several terms referring to DDR paradigm (van den Akker, 1999) such as design-based research (Wang & Hannafin, 2005), design experiments (Brown, 1992; Collins, 1992), development research (van den Akker, 1999), formative research (Reigeluth & Frick, 1999), developmental research (Richey et al., 2004), and design and developmental research (Richey & Klein, 2007). The parading they used is the same, but the underlying methods, goals, and approaches followed are slightly different from each other (van den Akker, 1999; Wang & Hannafin, 2005). Therefore, as it was pointed previously (van den Akker 1999; Richey and Klein 2007), DDR is a kind of umbrella term encompassing a wide variety of traditional research approaches, methods, strategies used in both quantitative and qualitative approaches. The previous authors used the term design and developmental research instead of any other equivalent terms (Richey & Klein, 2007, 2014). As a result, the researcher of this study adheres to the DBR methodology.

Many complex tasks in dynamic contexts embody inherently various unfolded uncertainties and problems that have always posed the greatest challenge for educational designers, especially in information and communication technologies (ICT) in education. This challenge becomes a motive for conducting development research to come up with a set of prescriptions that can be used to deal with and provide sustainable solutions for a wide range of design and development problems in education (van den Akker, 1999). For that reason, van den Akker (1999) called for the need to conduct development research in ICT to efficiently exploit and explore its potentials and rigorously cope with complexities inherent in ICT. DBR, different from other traditional research approaches, is a series of methodological toolkits that have great potential for examining and understanding variables in their naturalistic settings (Barab & Squire, 2004). Such endeavors result in the development of new theories, artifacts, and practices that affect learning and teaching, meet teachers' needs, improve instructional design and educational reforms (Barab & Squire, 2004; Reigeluth & Frick, 1999). In addition to its potential for decreasing the gap and strengthening the connection between theory and practice, design and development research holds great promise of providing design knowledge that educational researchers always seek in the field of educational technology (Reeves et al., 2004). Design knowledge involves contextual, social, and active processes (Perkins, 1986). Educational technology is a design field where design knowledge can be used to come up with design principles to solve performance problems related to teaching and learning and inform future decisions on implementation and development.

In literature, many characteristics and features of the design and developmental research that differentiate it from other approaches in terms of aim and context in professional practices have been identified by different authors. For example, as shown in Table 3.1, van den Akker (1999) provided key characteristics of development research and categorizes prominent elements in development research as preliminary investigation, theoretical embedding, empirical testing, documentation, analysis and reflection on process and outcomes, successive approximation of interventions in interaction with practitioners, and nature of knowledge from development research. Similarly, Wang and Hannafin (2005) described the main characteristics of DBR under five categories: pragmatic, grounded, interactive, iterative, integrative, contextual (see Table 3.2). As it can be clearly seen in Table 3.1 and Table 3.2, despite the different names used by two authors, both share some typical activities such as a collection of methods, techniques, and strategies employed under each element.

Table 3.1 Characteristics of experiment research

Characteristic	Explanation
Preliminary investigation	▪ A more intensive and systematic preliminary investigation of tasks, problems, and context is made. ▪ Literature review, consultation of experts, analysis of available promising examples for related purposes, case studies of current practices are some of the activities included.
Theoretical embedding Empirical testing	▪ Theoretical rationale for design choices is articulated. ▪ Clear empirical evidence is delivered about the practicality and effectiveness of the intervention for the intended target group in real user settings.
Documentation, analysis and reflection on process and outcomes	▪ Much attention is paid to systematic documentation, analysis and reflection on the entire design, development, evaluation and implementation process and on its outcomes in order to contribute to the expansion and specification of the methodology of design and development.
Successive approximation of interventions in interaction with practitioners	▪ Interaction with practitioners (in various professional roles: teachers, policy makers, developers, and the like) is essential. ▪ Interaction with practitioners is needed to gradually clarify both the problem at stake and the characteristics of its potential solution.
Nature of knowledge from development research	▪ The major knowledge to be gained from development research is in the form of (both substantive and methodological) 'design principles' to support designers in their task.

Table 3.2 Characteristics of design-based research

Characteristic	Explanation
Pragmatic	▪ Design-based research refines both theory and practice. ▪ The value of theory is appraised by the extent to which principles inform and improve practice.
Grounded	▪ Design is theory-driven and grounded in relevant research, theory and practice. ▪ Design is conducted in real-world settings and the design process is embedded in, and studied through, design-based research.
Interactive, iterative, and flexible	▪ Designers are involved in the design processes and work together with participants. ▪ Processes are iterative cycle of analysis, design, implementation, and redesign. ▪ Initial plan is usually insufficiently detailed so that designers can make deliberate changes when necessary.
Integrative	▪ Mixed research methods are used to maximize the credibility of ongoing research. ▪ Methods vary during different phases as new needs and issues emerge and the focus of the research evolves. ▪ Rigor is purposefully maintained and discipline applied appropriate to the development phase.
Contextual	▪ The research process, research findings, and changes from the initial plan are documented. ▪ Research results are connected with the design process and the setting. ▪ The content and depth of generated design principles varies. ▪ Guidance for applying generated principles is needed.

The characteristics of design and development research employed in this study are in line with the main characteristics described by Wang and Hannafin (2005) and van den Akker (1999). According to Richey and Klein (2007), the nature of the research problem and questions to be addressed and the type of research to be done, such as product, tool, and model determines the methods to be employed in the study. For that reason, the author of this study will not strictly adhere to some specific methods and strategies widely used in literature but rather select a variety of methods and strategies that best suit to the nature of the research problem and questions addressed in the study.

Depending on their focus and goals, Richey and Klein (2014) categorized design and development research projects as two major types: (1) research on products and tools and (2) research on design and development models. While the first one focuses on design and development projects of specific educational or non-educational products or tools, the second one focuses on the development, validation, and use of design and development models. Since the focus of the present study is to design and develop blended electronic and e-textile technologies in STEAM subjects, the first research category, research on products and tools, best fits and meets the goals aimed for achieving in this study. Research on products and tools involves an iterative and systematic collection of qualitative and quantitative data on the design and development processes of tool or product from analysis to evaluation (Richey & Klein, 2007).

In the literature, researchers offered design and development research models with different phases followed. The current study followed the procedures and guidelines offered by two leading authors for the design and development research (McKenney & Akker, 2005; Reeves et al., 2004). In their study, McKenney and Akker (2005) developed a computer-based tool or program, CASCADE-SEA, that can be used to facilitate the process between curriculum development and teacher professional development. They followed an iterative process of analysis, prototype design, evaluation, and revision. Specifically, as shown in Figure 3.1, the development of CASCADE-SEA was accomplished through four main phases: needs and context analysis (including literature review and concept validation), design, development, formative evaluation (including prototype 1, prototype 2, prototype 3, prototype 4) and summative evaluation (including final evaluation and query).

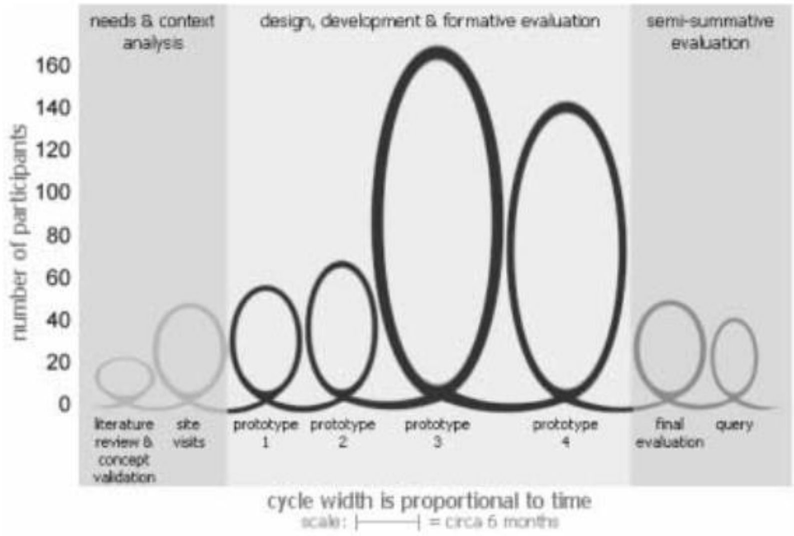

Figure 3.1. Display of the CASCADE-SEA (McKenney & Akker, 2005)

Consequently, the current study focuses on the comprehensive design and development of interdisciplinary hands-on activities for middle school students. As part of the design-based research agenda, this study used both qualitative and quantitative data collection methods to answer the research questions (Creswell & Clark, 2007; Richey & Klein, 2007). However, the main emphasis was given on qualitative techniques than on quantitative methods. The reason to choose both approaches is that a variety of qualitative techniques such as in-depth interviews, open-ended questions, and observations allows to explore, explain, and describe the variables and factors associated with the design of STEAM activities while implemented by teachers (or students) in their natural settings (Creswell, 2013). Consequently, the multiple data sources in DBR provide a comprehensive understanding of the educational activities, allowing for the identification of patterns, themes, and issues that may not be apparent from a single source of data.

3.3 Materials and tools

The camp was filled with a broader range of resources to support teachers' STEAM designs. Science teachers in both camps had access to both a great variety of textile and craft materials and a range of sewable electronics to use for their STEAM design. The camp materials ranged from programmable microcontrollers (Lilypad Arduino USB, Lilypad Arduino Simple Board) to a variety of sewable sensors (light, temperature, and color sensor) and fabric and textile items (felt, clothes, yarn, and so on.). The materials also included tools and sewable technologies such as Lilypad LEDs, Lilypad pixel board, conductive thread, e-textile battery, coin cell battery holder, Lilypad buzzer, USB micro cable, multicolored alligator clip, etc. Figure 3.2 below shows some of the sewable electronics used in the STEAM projects.

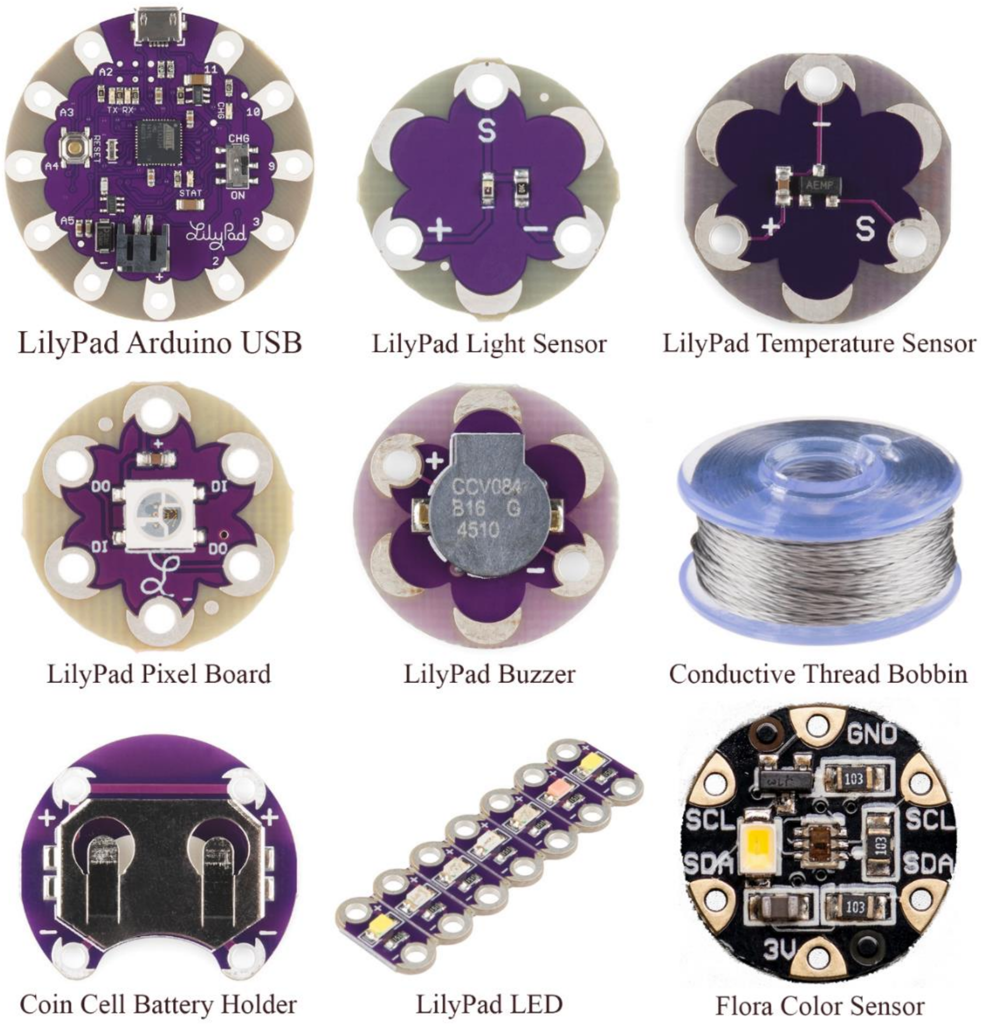

Figure 3.2. Some of the featured sewable electronics used in the camp

In addition to sewable electronics, there was a wide variety and sorts of textile and crafting materials and tools available in the camp (see Figure 3.3). Some of the textile materials such as felt, yarn, and regular (polyester-cotton) sewing thread were available in different colors and thicknesses. Besides, there were fabric and garments ready to be used by groups. Also, there were needle sets including needles of various sizes for different sewing purposes. Furthermore, fabric glue and nail polish were used by groups to secure the connections made by a conductive thread.

A metal ruler was given to each group so that they could use it to measure and draw a straight line. Also, each group had a digital multimeter on their design table to use for many basic applications such as measuring voltage and resistance, detecting short circuits, checking whether the circuit components work correctly, etc. Some of the other items and tools that were available in the camp are soldering iron, solder, precision knife, scissors, thread, embroidery hoops, small snips, glue gun, and glue sticks, etc. A complete list of materials and tools used in the camp is provided in Appendix J.

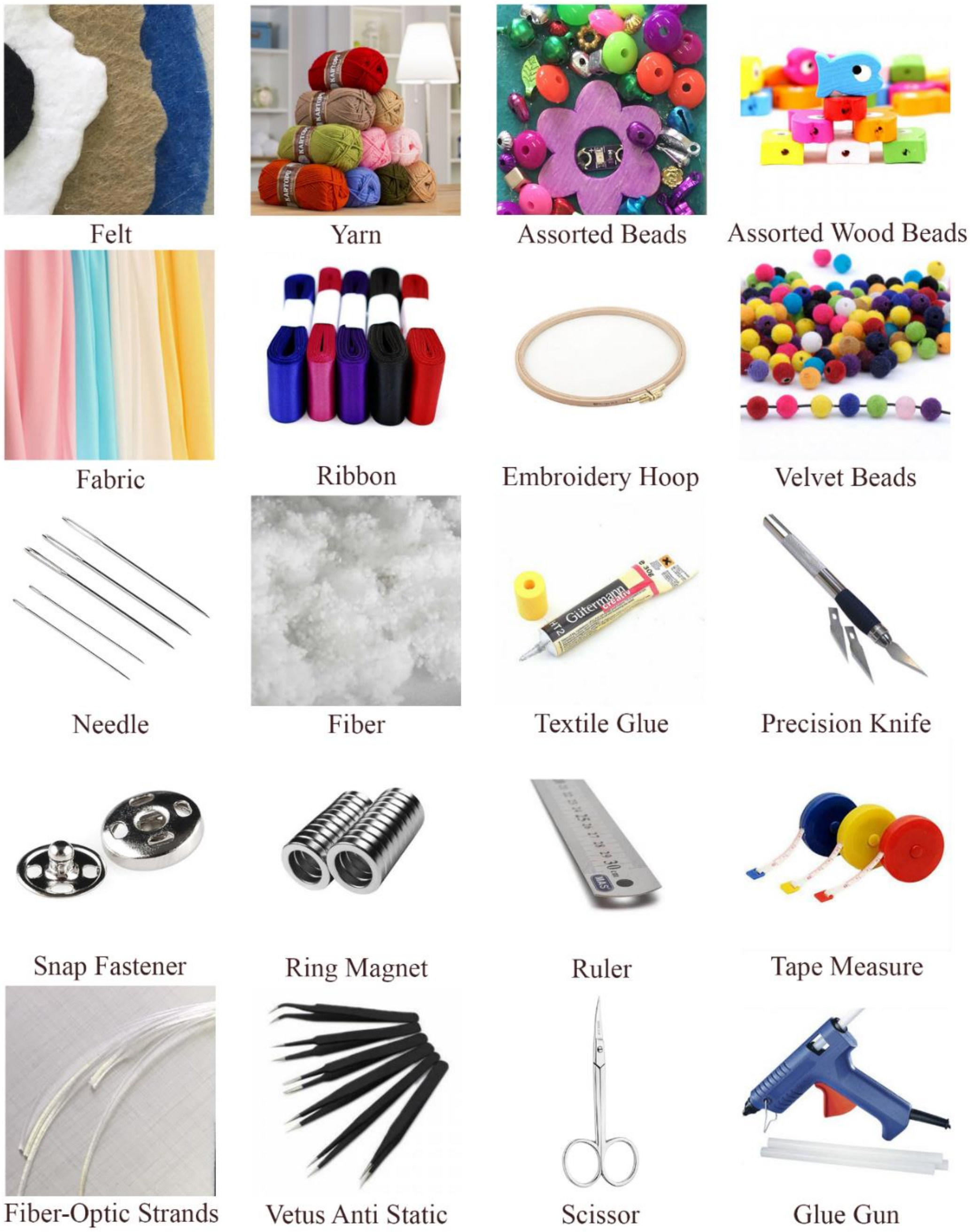

Figure 3.3. Some of the crafting and textile materials and tools used in the camp

3.4 The implementation of the study

The whole process of the study involved several activities: development of the first draft of the STEAM activities, pilot studies, improvement, and refinement of the piloted activities, the first camp, and the second camp. The primary data were gathered from two separate four-day STEAM camps. Table 3.3 below shows a summary of the study schedule. Besides, Table 3.4 depicts the timeline of the study.

Table 3.3 Summary of study schedule

Activities	Date	Participant type	Participant number	Explanations
The first pilot study	19 January 2017	Science teachers	35	Thirty-five science teachers engaged in designing two e-textile activities
The second pilot study	3-30 April 2017	Middle school students	5	Five middle school students engaged in designing two e-textile activities.
The third pilot study	19 June 2017	High school students	20	Twenty high school students engaged in designing an e-textile activity.
The first camp	27-30 January 2018	Science teachers	20	Twenty science teachers engaged in designing seven e-textile activities.
The second camp	1-4 February 2018	Science teachers	19	Nineteen science teachers engaged in designing seven e-textile activities.

3.4.1 Pilot study

A series of pilot studies were conducted with different groups of participants. Those preliminary studies varied from each other not only by when and where they were conducted but also by the type of the participant involved and the sort of the STEAM activities applied. The STEAM activities that were used in pilot studies had been designed and developed by the researchers based on the results of the needs and content analysis. Table 3.4 depicted the information related to the preliminary pilot studies including the date of conduction, participant type, completion time, and the number and type of the STEAM activities conducted. The detailed description of the participant groups was given below in chronological order.

The first pilot study was conducted with a group of 35 middle school science teachers coming from different schools scattered in various regions of Turkey. Among the participants whose ages ranged from 25 to 35 years old, 15 were male, and 20 were female. Science teachers in a group of two or three were exposed to two STEAM activities. It took approximately five hours for the groups to complete the whole design of the activities. The activities were conducted in a large classroom on January 19, 2017, at the faculty of education at Eskisehir Osmangazi University, Turkey. The following three photos (Figure 3.4, Figure 3.5, and Figure 3.6), which were taken during the first pilot study, show the groups of science teachers who works on their project design. In the activity, teachers needed to design and craft a project design using the given textile materials (garment, felt, fabric, glue, conductive thread, needle, and other crafting tools) and six components (a Lilypad, four LEDs, and a lithium-ion battery).

Figure 3.4. A group of teachers cutting fabric for their project design

Figure 3.5. A group of teachers finalizing their project design

Figure 3.6. Three groups presenting their finished project designs

The second group of participants in the pilot study was five 5th grade middle school students at METU college. They were in the 11-14 age range. While one of them was female, four of them were male. Two different STEAM activities were given to the students through which they individually designed their wearable projects. Since students had only one hour a week after school to work on their projects, it took nearly one month to finish the activities. The activities were implemented in a computer lab on 3-30 April 2017 at METU Development Foundation Middle School, Ankara, Turkey.

Table 3.4 Descriptive information about pilot studies

Participants	*N*	Date	Time (hours)	STEAM activities (numbers)
Science teachers	35	19 January 2017	5	2
Middle school students	5	3-30 April 2017	4	2
High school students	20	19 June 2017	2.5	1

The third group of participants in the pilot study consisted of 20 11th grade high school students coming from different schools in different provinces of Turkey. The number of female and male students was 12 and 8 respectively. Their ages ranged from 15 to 19 years old. The students in groups of two engaged in making one hands-on activity in two hours. The activity was conducted on 19 June 2017 at Audio-Visual Systems Research and Production Center (GISAM) in METU, Ankara, Turkey.

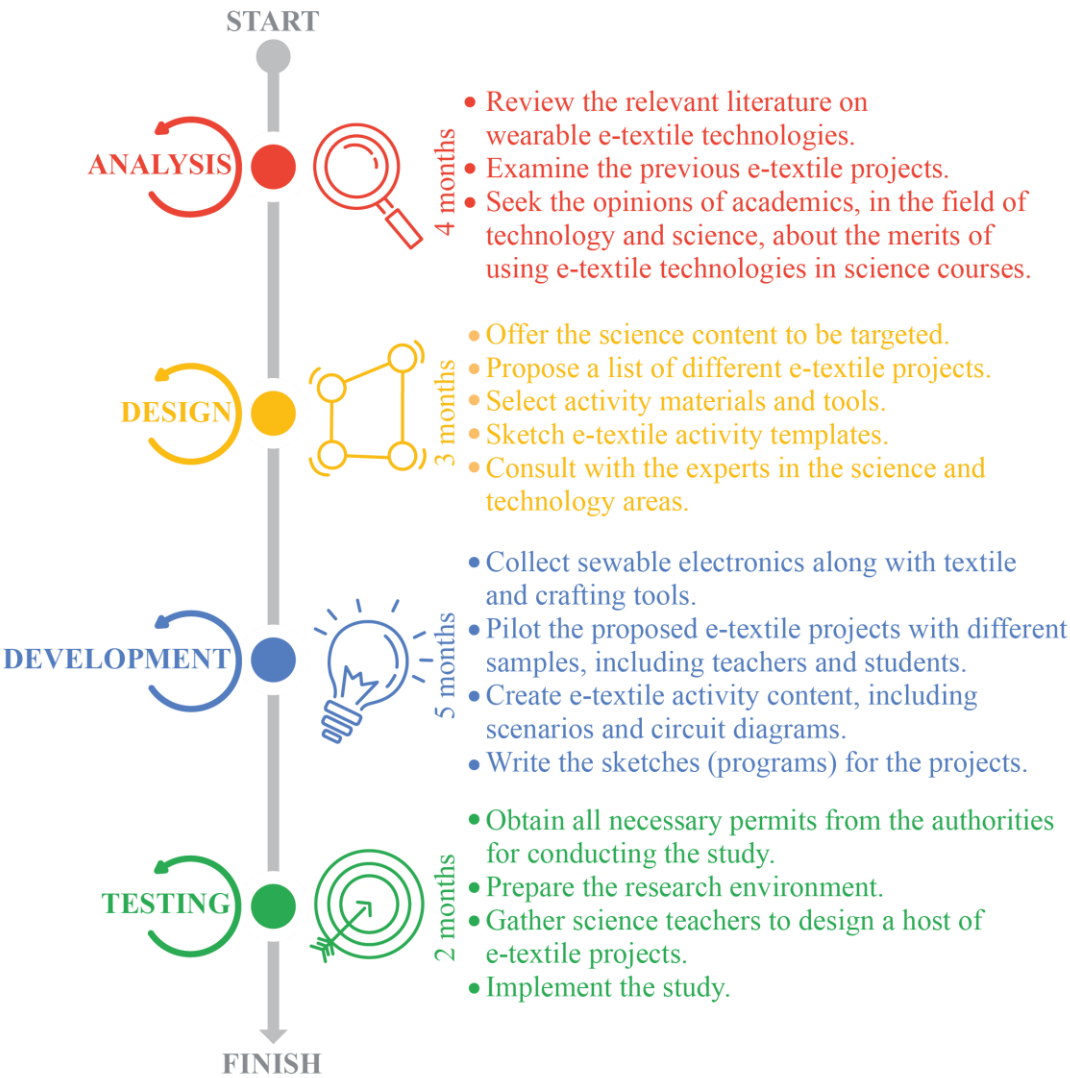

Figure 3.7. Timeline of the research study

3.4.2 STEAM camp activity booklet

The camp program was embedded into a STEAM camp activity booklet that included all STEAM activities and the additional documents in the main camp (Appendix H). The activity booklet composed of three main sections: materials and tools, helpful and assistive information, and STEAM activities, respectively. There was a total of seven STEAM activities arranged in order of difficulty and complexity level. Table

3.5 below provides further descriptive information about the contents of the STEAM camp activity booklet.

Table 3.5 STEAM Camp Activity Booklet

Title of the Content	Descriptions
Materials and Tools	The first section of the booklet was allocated to illustrate e-textiles tools and materials used in STEAM activities. It had two parts: wearable e-textile technologies and art and design tools.
Wearable E-Textile Technologies	This part presented different sorts of e-textile materials used in activities. Information in this part included a clear image of each used e-textile equipment along with its name.
Art and Design Tools	This part presented a variety of art and design tools used for crafting in activities. Information in this part included a clear image of each design and crafting tool along with its name.
Helpful and Assistive Information	The second section of the booklet provided some useful information and tips on how to do sewing and use a digital multimeter in activities. Additionally, this section presented design thinking stages.
An Example of How to Sew a Simple Circuit into Felt	This part provided a step-by-step demonstration of how to design a simple e-textile circuit with one LED light and coin cell battery.
Use of Digital Multimeter	In this part, a simple introductory tutorial was provided to introduce necessary information about a multimeter and to show how to use it for measuring basic things like voltage, current, resistance, and continuity.
Design Thinking Stages	The last part of the second section was reserved for the description of the design thinking process adhered to in activities.
STEAM Activities	The third and last section of the booklet was exclusively separated for the description and presentation of the STEAM activities.
STEAM Activity 1: Sewing and Crafting LED Badge Using E-Textiles	The first STEAM activity was an introductory activity explicitly designed to help participants getting familiarity with wearable circuit components and sewing with conductive thread. In this activity, participants were expected to craft a badge using a simple, functional circuit with an LED light, coin cell battery, and conductive thread.

Table 3.5 STEAM Camp Activity Booklet (Continued)

Title of the Content	Descriptions
STEAM Activity 2: Sewing and Crafting LED Wristband Using E-Textiles	The second STEAM activity was a bit challenging than the first one. In this activity, participants were expected to craft a wristband using a parallel circuit with three LED lights, coin cell battery, conductive thread, and snaps or ring magnets.
STEAM Activity 3: Sewing and Crafting LED Necklace Using E-textiles	The third STEAM activity was different from the second in terms of the type of circuit used. In this activity, participants were expected to craft a necklace using a series circuit with two LED lights, two-coin cell batteries, conductive thread, and ring magnets or snaps.
STEAM Activity 4: Sewing and Crafting Color Changing Star Cluster Using E-Textiles.	The fourth activity and other activities that follow are more complex than the previous ones because of demanding more effort and requiring to form a codable circuit. In this activity, participants were expected to craft a color-changing star cluster with a Lilypad Arduino USB, two LED lights, fiber optic light, an RGB power LED, and conductive thread.
STEAM Activity 5: Sewing and Crafting Light-Responsive Lighthouse Using E-Textiles	The fifth STEAM activity included a sensor technology capable of detecting the level of ambient light shining. In this activity, participants were expected to craft lighthouse with a Lilypad Arduino USB, a Lilypad light sensor, a Lilypad pixel board, and conductive thread.
STEAM Activity 6: Sewing and Crafting Heat-Responsive Thermometer Design Using E-Textiles	The sixth STEAM activity included a sensor technology capable of detecting ambient temperature. In this activity, participants were expected to craft a thermometer with a Lilypad Arduino USB, a Lilypad temperature sensor, a Lilypad buzzer, four LED lights, and conductive thread.
STEAM Activity 7: Sewing and Designing Color Changing Scarf Using E-Textiles	The sixth STEAM activity included a sensor technology capable of detecting the color of an object. In this activity, participants were expected to craft a scarf with a Lilypad Arduino USB, a Flora color sensor, seven Lilypad pixel board, and conductive thread.

3.4.3 Part 1: The first camp

The first STEAM camp was implemented during January 27-30, 2018, at GISAM located on the METU campus. The camp was funded by a grant from Embassy of the United States of America, Ankara, Turkey, and organized in collaboration with GISAM and BILTEMM at METU with the project named “Moving Teachers and Students Forward by Innovative STEAM Activities”. Moreover, GISAM and BILTEMM worked collaboratively to seek out the participants and coordinate the camp.

3.4.3.1 Participants

GISAM and BILTEM worked collaboratively to seek out the science teachers for the camp. Since BILTEM had previously organized and involved in several teacher workshops related to STEM skills, they already built a large pool of teachers from different schools located in different regions of the country. The middle school science teachers from the pool were called for attending to four-day hands-on and interactive STEAM activities. The announcement of the camp was not only made via an email message but also through social media platforms such as Facebook and Twitter. In the announcement message, teachers were partly informed about the camp and asked to check the camp website for further information using the website link included in the message. A website with URL http://modak.gisam.metu.edu.tr/ was designed to provide all the announcements and necessary information related to STEAM camp. Science teachers who were willing to participate in the camp were given a link to a Google form where they answered some closed- and open-ended questions. The information gathered through those questions was analyzed by the researcher, a doctoral student, and a university instructor from the same department for the selection of participants to be included in the shortlist. The four main criteria were used for creating a shortlist of twenty teachers, along with five substitute or replacement teachers in case some teachers who had agreed to participate did not show up. Specifically, a selection priority was given to the teachers who (1) had little or no experiences with similar activities before, (2) new and young in the teaching profession, (3) interested in STEAM fields, especially arts and crafts, and (4) came from public schools in rural and disadvantaged cities of the country. Additionally, in case of the unexpected and sudden absence of teachers from the shortlist, some of the substitute teachers were purposively selected from the schools whose locations, comparing to the others, were close to the camp place.

Substitute teachers replaced three teachers who didn’t come to the camp. There was a total of 20 science teachers coming from schools of different socioeconomic status levels and various geographical regions of Turkey. The camp curriculum was designed for middle school science teachers and also students at 5th, 6th, 7th, and 8th grades. Therefore, the camp curriculum was specifically designed in line with the middle school curriculum to suit the subjects for STEAM activities.

Table 3.6 shows the descriptive statistics about the participants in the first camp. As indicated in the table, the participants composed of twelve women and eight men whose ages ranged from 23 to 45 years old. As for their years of professional experience, most of the participants had professional experiences in the range of one and five years (n=7), followed by six and ten years (n=5). There were three participants under one-year of professional experience. The average professional experience of the participants was seven years. Table 3.6 shows the further information about the participants’ age and professional experiences.

Table 3.6 Age and professional experience of the participants in the first and second camp

Professional experience (years)	n
Below 1	3
1-5	7
6-10	5
11-15	3
16-20	1
21-25	1
Age	
21-25	3
26-30	6
31-35	6
36-40	3
41-45	2
46-50	-
51 and above	-

Figure 3.8 below illustrates the distribution of the cities or provinces where the participants live. As could be seen from the figure, participants came from ten different parts of Turkey. Specifically, when the number of participants sorted the provinces, it would be seen that most of the participants were from Ankara (n = 9), followed by Antalya (n = 2) and Gaziantep (n = 2).

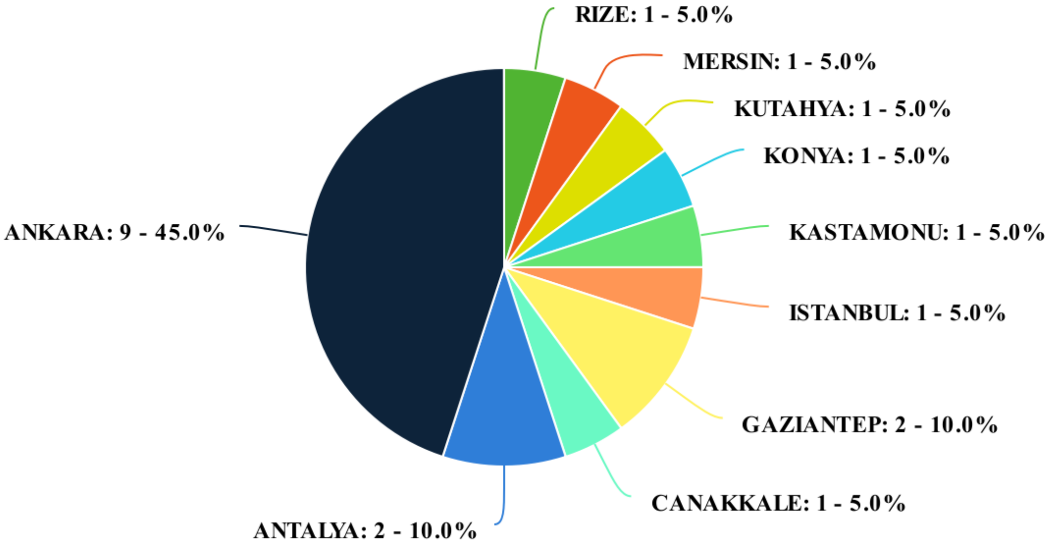

Figure 3.8. Distribution of the first camp's participants in terms of provinces

3.4.3.2 Facilitators

A total of six facilitators, including the researcher, attended the first camp (see table 3.7). Of the facilitators, three were graduate students (the researcher and instructor 1), and three were preservice science teachers at their final year of the university (instructor 2, 3, and 4). Like the researcher of this study, one of the graduate students (instructor 1) was doing his Ph.D. study on wearable technologies in education. Therefore, he had experiences in hands-on activities and familiarity with the e-textile technologies used in STEAM activities. The other three facilitators are undergraduate students who were in the final year of their computer education and instructional technology program. Since they were working on a STEAM design as a part of the term project, they had experiences and knowledge about e-textile technologies.

Table 3.7 Gender and grades of the first camp’s participants

Nickname	Gender	Experience
The researcher	Male	STEAM activities
Facilitator 1	Male	Wearable technologies, interdisciplinary activities
Facilitator 2	Male	E-textile technologies, STEAM activities
Facilitator 3	Male	E-textile technologies, STEAM activities
Facilitator 4	Male	E-textile technologies, STEAM activities

3.4.3.3 Camp place

The camp was conducted in a large hall at GISAM. The room, which would be called the making space from now on, has a quite ample area. The place is usually used to shoot a variety of educational and instructional videos and films. The making space was big enough to let more than 20 teachers walk around and work on their STEAM designs smoothly. The number of tables and chairs in the making space was sufficient to allow groups of teachers to have a seating place and the place for group working. Figure 3.9 displays the physical layout of the making space.

Figure 3.9. Physical layout of the camp space

As clearly indicated in Figure 3.9 above, there are eight medium-sized tables with plenty of chairs and a large rectangular table in the middle of the room. While the tables are used for collaborative group work, the large table functions as a shared space where groups came and picked the particular materials they want to utilize for their design. All the arts and crafting materials, irrespective of whether the groups will make use of it or not, were first categorized and then placed on the shared table so that groups can easily find whatever they are looking.

3.4.3.4 The camp program

The four-day camp schedule included an introduction, opening presentations, the making of hands-on STEAM activities, and group projects. Accordingly, the camp was started with a small introduction ceremony where all the facilitators and science teachers introduced themselves one by one. Then, two instructors (female and male) who were studying fashion and textile design at Atılım University, Ankara, Turkey gave a 45-minutes joint presentation on the evolution of the fashion and design over the times. In the presentation, the instructors inform participants about craft, fashion, and design and the way they are interconnected. Also, they showed some exemplary and non-exemplary fashion designs to inspire participants to gain insights into some fashion design principles. Besides, they gave participants some practical fashion design tips and strategies to consider while crafting their STEAM project.

Once the presentation was over, participants had a five-minute break. After the break, the plan was to form a group of two individuals with a mix of at least one female or one male. However, despite being told several times by the facilitators, most of the teachers persisted to choose their group members. Furthermore, the participants were supposed to create groups of at most two individuals, but their inclinations towards working with their gender resulted in groups of two and three members. As a result, there were two groups of three members and seven groups of two members.

After forming the groups, a hard copy of the camp program and the activity booklet were handed out to each group, which was followed by a presentation that introduced and informed the participants about the implementation process of the activities throughout the camp. The presentation covered information about the types of STEAM activities participants were going to engage and the materials to be used, including sort of sewable electronics and the variety of arts and crafting tools.

After that, the participants were encouraged to ask any specific or general question they had in mind related to the camp. After that, the participants filled out a pre-assessment form composed of three parts: demographics, a questionnaire with 16 items, and two open-ended questions. After the five-minute break, the first STEAM activity started at 11.10 am and completed at 12:10 am. Then, a one-hour lunch break followed. The amount of time allocated for the STEAM activities could be examined in the camp program (Appendix H). However, in general, throughout the four-day camp, the groups of participants were encouraged to complete their STEAM designs within the time ranges specified for each activity in the camp program.

Figure 3.10. A group of teachers showing their project design

Besides, during the making of the activities, the researcher continuously kept the groups informed about the type of activity they were involved so that groups understood what they were dealing with and what designs they were expected to make. For this, at the outset of each STEAM activity, groups of teachers were briefly informed about the type of design they were expected to produce and e-textile materials they could use for the design. Also, groups were told to follow the design thinking stages during the project design process (Appendix I). The booklet given to each group included most of the information they needed to have for making the activity, but they first needed to learn how to read and follow the instructions in the booklet. What the facilitators were doing during the project design was partly about helping groups learn how to follow the booklet instructions.

Figure 3.11. Project design samples of badge, wristband, and necklace

During the camp, there was free coffee, tea, and water for each day from 8:00 am to 5:00 pm. Coffee and tea machine and 500ml water bottles were situated at the entrance of the camp space. Science teachers were told that they could take any one of them whenever they wanted as long as they were extremely careful about not pouring it over their project and e-textile materials. In addition to drinks, different types of snacks, including bagels and pastry, were given two times a day, morning and midafternoon. Additionally, a free lunch was given to the participants each day in a restaurant close to the camp.

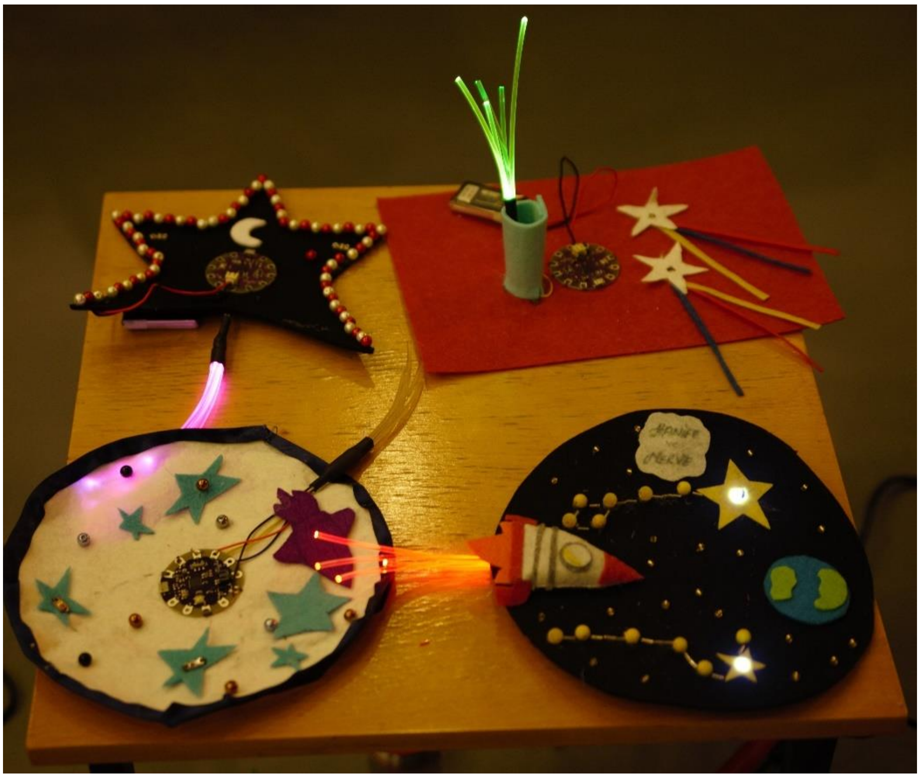

Figure 3.12. Project design samples of star cluster project

3.4.4 Part 2: The second camp

The second camp was also implemented at GISAM from February 1 – 4, 2018, with the support of the Embassy of the United States of America, Ankara, Turkey. Both GISAM and BILTEM again organized the camp, including the tasks involved in managing the applications and acceptance of science teachers, dealing with foods and drinks, and arranging the camp place. Nineteen science teachers participated in the second camp. However, lessons from the first camp allowed us to make a bunch of changes to the camp process before proceeding to the second camp.

At the outset of the first camp, the researcher told the facilitators to informally get information from teachers by asking them questions about the camp process during the break time and carefully observe the groups working on their design to discover the parts of the design that needed to be adjusted. Consequently, the first camp results, accompanied by the data from observations and experiences, were evaluated together with the facilitator 1 and the project director who had actively involved in the camp and also collaborated in preparing the STEAM activities. All these efforts were made to determine the significant adjustments and changes to the STEAM activities.

Figure 3.13. A group of teachers designing and sewing lighthouse project

A consensus was reached on several changes. Firstly, the amount of introductory information given at the beginning of every STEAM activity was increased in the second camp upon the request by teachers from the first camp. Secondly, the groups in the first camp sought more assistance and help than five facilitators could handle by themselves in time (two facilitators per group). Therefore, the number of facilitators was increased so that there could be one facilitator per group. Thirdly, the content of the booklet was rearranged. The parts, an example of how to sew a simple circuit into felt and use of a digital multimeter, that were at the end of the booklet in the first camp was brought to the front of the booklet in the second camp. Fourthly, in the first camp, groups did not get into writing any program code or programming their STEAM project. Instead, the activity code, which was previously prepared for each STEAM activity by the researcher, were directly given to project groups as soon as their project design was ready to be tested. Yet, groups were allowed to change the code to observe the effects on the project circuit as long as they had spare time. In the second camp, however, there was an additional small presentation at the end of each activity explaining groups how the given program code works line by line. Fifthly, even though the first camp was fully equipped with a wide variety of materials, there were some materials detected to be either missing or inadequate. Those materials were supplied in the second camp. Lastly, because of teachers' unfamiliarity with e-textile technologies, sewing wearable electronics with the conductive thread was one of the challenging parts that took a considerable amount of time in the first camp. Therefore, the facilitators who were assigned to the groups in the second camp were instructed to get involved in sewing with groups in the first activities.

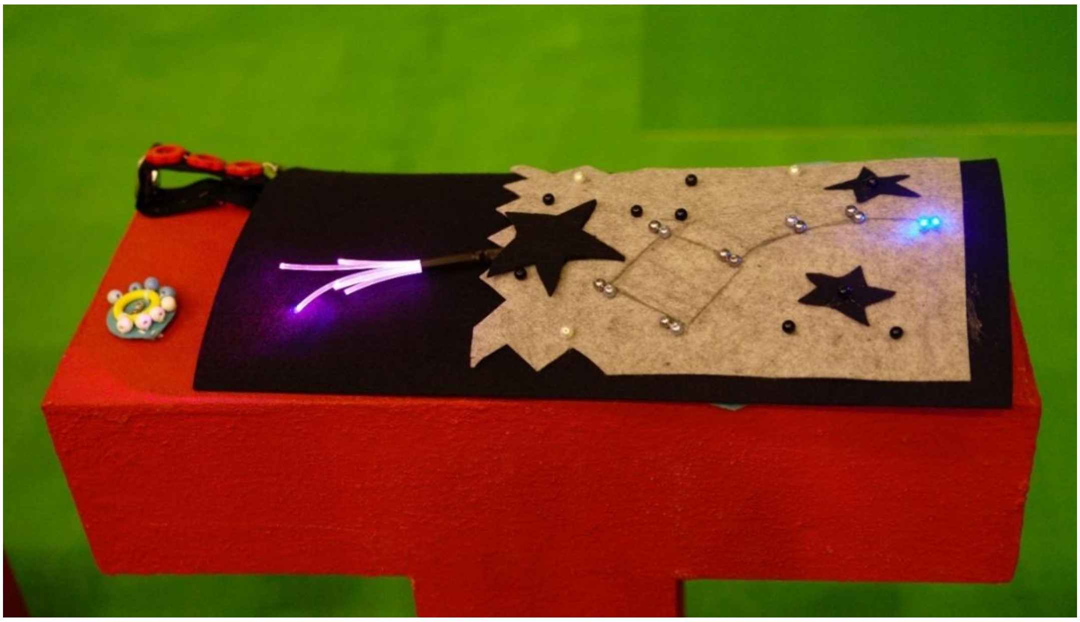

Figure 3.14. Project design samples of star cluster, badge, and wristband

3.4.4.1 Participants

The second camp hosted 19 science teachers from schools of different socioeconomic status levels and various geographical regions of Turkey. Like the first camp, in the latter camp, the four main criteria were used for creating a shortlist of twenty teachers, along with five substitute teachers in case of absences. Unfortunately, six science teachers in the shortlist did not attend to the second camp. Among those participants, only two informed the investigators in advance that they would not be able to participate in the camp. The remaining four did not show up on the first day of the camp and the days following. To compensate for the unexpected absence of participants, substitute teachers were called and invited to come as soon as they could. Consequently, a total of nineteen science teachers attended to the second camp.

Of the participants, 12 were female, and 7 were male. Their ages ranged from 23 to 52 years old. As for the participants' professional experiences, most of the participants had professional experiences in the range of one and five years (n=8), followed by six and ten years (n=5). There were five participants under one-year of professional experience. The average professional experience and age of the participants were 29.26 and 4.74 years respectively. Table 3.8 shows the further information about the participants' age and professional experiences.

Table 3.8 Age and professional experience of the participants in the second camp

Professional experience (years)	n
Below 1	5
1-5	8
6-10	4
11-15	1
16-20	-
21-25	1
Age	
21-25	5
26-30	8
31-35	5
36-40	-
41-45	-
51 and above	1

Figure 3.15 below shows the distribution of the cities where the participants live. As could be seen from the figure, they were from six different parts of Turkey. Specifically, when the number of participants sorted the provinces, it would be seen that most of the participants were from Ankara (n = 12), followed by Konya (n = 2) and Kocaeli (n = 2).

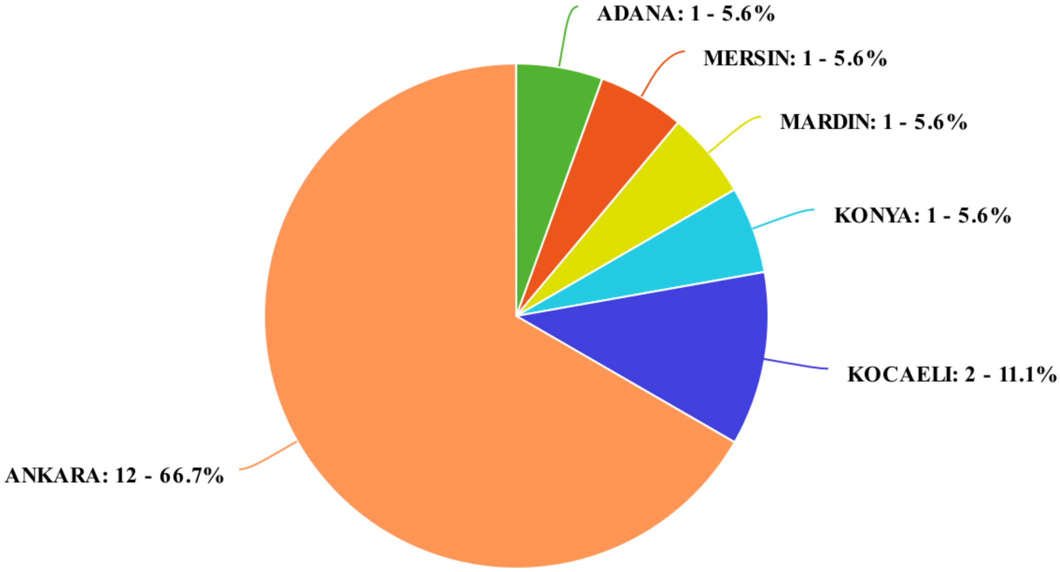

Figure 3.15. Distribution of the second camp's participants in terms of provinces

3.4.4.2 Facilitators

The number of facilitators increased in the second camp. In addition to the five facilitators from the first camp, three new female facilitators joined the latter camp, which became eight in total. While one of them was a graduate student doing her master's study on elementary mathematics education, the other two are undergraduate students in their final year of science education program. Three of them had involved in various educational activities in STEM fields and were very interested in art, crafting, and hands-on activities.

3.5 Researcher's Role

The researcher endeavored to take as many roles as possible to ensure the smooth running of the main phases of the study, namely analysis, design, development, evaluation and documenting. Among the positions taken, the researcher's role as a participant-observer was appeared to be more vital and productive especially in pilot studies when the design and development of STEAM activities were at their infancy.

The drawing of the inferences, revisions, refinements, improvements, and amendments to draft STEAM activities all came out of the researcher's experiences in observing and participating in STEAM activities.

In phase 1(needs and context analysis), together with continuous support from subject matters, designers/developers, and art teachers, the researcher carried out a comprehensive literature review to determine the science topic and the best-fitted wearable e-textile technologies that could be leveraged to teach science subjects. The researcher was aware that getting an understanding of the learning context in which science subjects and wearable e-textile technologies were to be merged plays a crucial role in the design and development of STEAM activities. Therefore, the researcher spent much time and put more effort into learning and analyzing the accumulation of literature sources to get familiarity with science subjects and wearable e-textile technologies.

In phase 2 (design and development of prototype 1), the researcher took multiple roles. The researcher did not only design and develop a series of STEAM activities for different types of participants in the pilot study, but he did also supply a bunch of necessary activity materials to them. Throughout the study, he took the role of supplier of materials for STEAM activities. For doing that, he first sought out wearable e-textile technologies and pieces of tools and apparatus that might be needed for STEAM activities and then found them and bring them together so that participants could craft their product without complaining about the shortage of materials.

In phase 3, 4, and 5 (Testing of prototype 1, 2, 3), apart from the roles mentioned above, the researcher was in a position of interviewing participants about their experiences, views, thoughts, and opinions related to the STEAM activities in which they interactively engaged. Interview process doom to be a burden to an unqualified and inexperienced interviewee. However, the researcher had previous experiences in conducting face-to-face semi-structured interviews for academic purposes. Therefore, he had the capability of making a close rapport and building trust with interviewees. Because creating mutually trusting relationships and excellent communications with respondents are beneficial to the interviewer to gather good quality of data (Marshall & Rossman, 2011).

Besides, during the implementations of STEAM activities, the researcher attended as a participant-observer while observing groups of science teachers making and doing their designs or products (Wolcott, 1999). The researcher of this study also prepared a STEAM Camp Activity Book including all necessary information about the individual activities as well as some useful tips and information. The researcher guided and assisted each group of science teachers as much as possible while they were crafting their STEAM product following the information provided in the Activity Book.

3.6 The design thinking process

In the camps, the teachers in groups followed design thinking stages to develop new and innovative design solutions to the specified STEAM design challenges. The design thinking stages used in this study were adapted from the design guidelines and procedures by NASA (2015) and IDEO (2012). Both Nasa's engineering design process and IDEO's design thinking for educators emphasize the development of an innovative solution to a design challenge by a collaborative effort. Nasa's engineering design process composes of eight stages: (1) identify the need or problem, (2) research the need or problem, (3) develop possible solutions, (4) select the best possible solution(s), (5) construct a prototype, (6) test and evaluate the solution(s), (7) communicate the solution(s), and (8) redesign. Each of these stages is interconnected and depends on one another. A successful design solution is likely to be produced when these steps are taken as guidance. However, skipping one stage can lead to a failure in the stage(s) followed and this makes the final design flawed or unproductive. On the other hand, IDEO's design thinking consists of five phases: (1) discovery, (2) interpretation, (3) ideation, (4) experimentation, and (5) evolution.

Like Nasa's engineering design stages, IDEO's design thinking phases revolve around a design challenge to address throughout the design process.

In this study, the design process of a STEAM project is where design thinking stages are put into action. In this study, the seven phases, as illustrated in figure 3.16 below, led to the groups' project design process (Appendix I). in other words, the groups of science teachers adhered to these stages while designing and crafting their project design. Every design thinking stage is accompanied by a description of that stage, informing participants about the series of tasks they need to carry out during the stage.

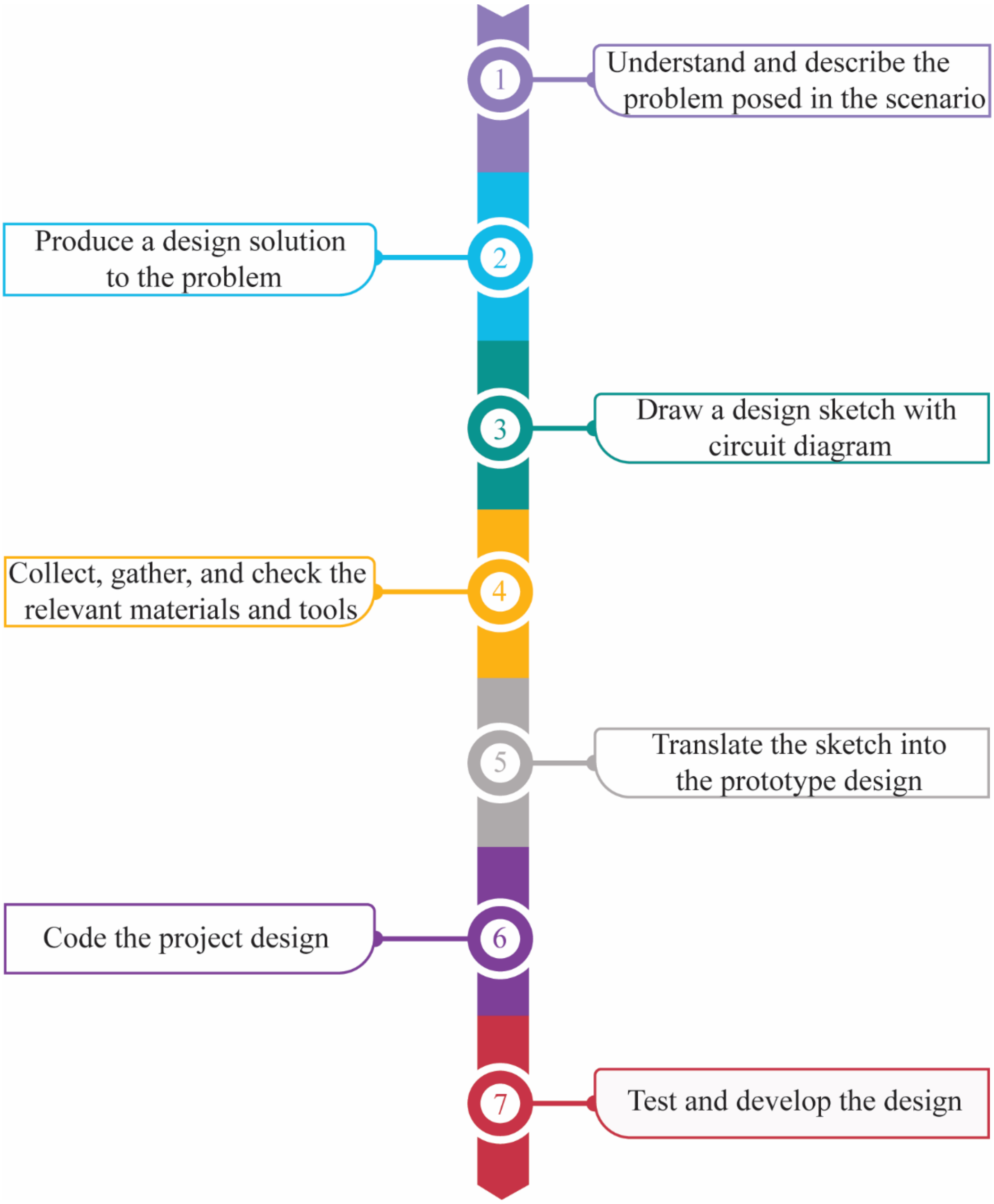

Figure 3.16. The design thinking stages followed during the design process of the STEAM projects

3.7 Data collection

This part provided information regarding the data collection forms or instruments used in the study to ensure the documentation of the design, development, and evaluation of STEAM activities. Each data collection tool, with its unique type of data, as described below, contributed to the richness and quality of the data set collected in the current study.

3.7.1 Data collection instruments

Data collection instruments hold an important place in a research design. The researchers using design and development research in their studies tend to use various data collection methods such as work logs, surveys, questionnaires, interview protocols, and observations (Richey & Klein, 2007). The current study employed various data collection tools, including interviews, surveys, open-ended questions, observations, and design artifacts. The following is detailed information relating to each of these tools. Moreover, Table 3.9 below shows these tools' characteristics and the purposes aimed to achieve through them.

Table 3.9 Description of the data collection methods

Stage	Data collection method	Data collection type	Closed-ended questions	Open-ended questions	Participants	Purpose
After the camp	Interview	Individual	-	12 (34 probes)	10 (5 women, 5 men)	-Analyze and identify a comprehensive view of teachers' STEAM design experiences. -Identify the prominent design principles.
Before the camp	Pre-evaluation survey	Individual	Demographics, 16 items	2	39 (24 women, 15 men)	-Identify teachers' views on an interdisciplinary approach. -Explore teachers' intentions in participating in the camp.
After the camp	Post-evaluation survey	Individual	Demographics, 74 items	9	31 (20 women, 11 me)	-Evaluate the whole camp process. -Get teachers' learning experience and opinions about the design of STEAM projects.
During the camp	Activity evaluation form	Group	-	6	16 group	-Identify teachers' thoughts and experiences of individual STEAM project design. -Identify the design principles.
Throughout the camp	Observation	Individual, group	-	-	39 teachers	-Explore teachers' experiences and challenges of designing and crafting e-textile project. -Identify the design principles.
After the camp	Design artifacts	Group	-	-	128 designs	-Analyze teachers' project designs in terms of technical, aesthetic, and functional aspects.
After the camp	Evaluation form	Individual	-	5	4	-Get teachers' practical experiences of conducting STEAM activities after the camp. -Explore how successfully teachers were able to transfer camp knowledge and skills to different learning settings.

3.7.1.1 Interview Schedule

The interview protocol is widely used instrument in design and development research. It refers to a tool of inquiry researchers employ to find answers to research questions of the study by asking participants a series of relevant questions (Patton, 2002). The interview is a beneficial instrument because it lets the researcher collect a large quantity of data from participants to understand their thoughts and beliefs and explore the events and what triggered those events (Richey & Klein, 2007). In this study, in-depth exploratory interviews in semi-structured form were conducted to address the research questions.

In this study, the interview protocol is divided into two sections: an introduction and a list of interview questions (see Appendix A). The introduction section served as a consent form that informed respondents about their rights as an interviewee, asked for their voluntary participation, and assured them that the data collected from them would both anonymous and confidential. The second section included twelve main questions, accompanied by a few sub-questions and probes. Interview questions were grouped according to some specified themes: content-context, design, design-related problems and suggestions, creativity, interaction, measurement and evaluation, integration, transferring, and arts.

The reliability and validity of the interview questions were ensured through iterative review and supervision by two experts and one doctoral student. In collaboration with a doctoral student with experience in the design and development of e-textile projects, the researcher wrote research questions. The questions were organized in such a way that they addressed each of the research questions. One expert first reviewed interview questions and suggested revisions. Based on the expert’s feedback, the researcher revised the interview questions and sent them to another expert with knowledge of STEM/STEAM pedagogies. The second expert inspected interview questions and suggested small revisions for the clarity and wording of the questions.

The process of revision continued at rehearsals. The researcher conducted an interview with a doctoral student to test and improve the final version of the interview questions. While conducting the interview, the researcher inquired of the doctoral student about the clarity and understandability of the questions, as well as ways to improve them further. Using the iterative process mentioned above, the researcher finalized the interview questions (see Appendix A).

3.7.1.2 Survey

In addition to the interview protocol, a survey was used to elicit teachers' thoughts, opinions, and experiences regarding the design and development of STEAM activities. The survey included both closed-ended and open-ended questions to get more comprehensive data about STEAM activities.

In pilot studies, twelve open-ended survey questions were utilized as the primary data collection instrument to have respondents evaluate STEAM activities in terms of many aspects. In the pilot study, STEAM activities were conducted by different groups of participants, including middle school science teachers and students at different levels. It was presumed that collecting rich data from each respondent would require a particular data collection instrument. Besides, using open-ended questions was considered more appropriate because they permit the researcher to ask non-leading questions, take responses without forcing the participant, and get individualized views (Fraenkel et al., 2012).

3.7.1.3 Observations

The field-based observation was one of the techniques that was immensely used, especially in the pilot study. Marshall and Rossman (2011) characterized observation as a technique of capturing data related to various activities and people in the setting. This study's researcher benefitted from the observation technique, particularly direct and participant observation, to observe some aspects of participants' behaviors during the implementation of STEAM activities. As a natural form of ethnographic research, direct observation has many advantages (Patton, 2002). For example, it enables the researcher to situate participants in the context where they interact and carry out activities and involve directly with the learning setting and people in that setting. Besides, it helps the researchers capture the things people in the setting may either not discover before or fail to see and to learn things that aren't revealed in the interviews.

During the implementation of STEAM activities, the researcher did not just serve as an assistant who guided and helped groups in the project design process, but he was also in a position of observer striving to learn group activities through observing and participating in those activities.

The researcher's complete immersion in the design and implementation of STEAM activities enabled him to experience and observe the dynamics of the project design process. Besides, the documentation of the researcher's experiences and reflection on STEAM activities derived from continuous observations in settings where teachers engaged in making their project design.

3.7.1.4 Camp evaluation forms

There are two evaluation forms used in the camps: pre-evaluation and post-evaluation form. The first form is applied at the beginning of the camp to get the participants' attitudes towards an interdisciplinary approach and its integration into the school curriculum along with their expectations from the camp. On the other hand, the second form is applied at the end of the camp to investigate participants' experiences and evaluations of the STEAM activities in the camp.

3.7.1.5 Pre-evaluation form

The pre-evaluation form consisted of three parts: demographics, a questionnaire, and open-ended questions (Appendix B). The demographics part obtained information about the participant's teaching profession, academic career, and personal details. The second part included a scale consisting of 16 items that assessed participants' perceptions and attitudes towards interdisciplinary teaching. The original version of scale was developed in English (Bayer, 2009). Previous authors adapted the scale into Turkish and established its reliability and validity through confirmatory factor analysis (Karahan et al., 2017). The authors found that the scale comprised of one factor and had Cronbach's Alpha reliability coefficient of .71, which was moderate.

Participants were asked to express the degree of their agreement with the statements in the scale on a 5-point Likert-type scale ranging from '1' = 'strongly disagree' and '5' = 'strongly agree.' The third part included two open-ended questions that elicited teachers' reasons for coming to the camp and their plans to implement similar hands-on activities in their school in the future. Although both camps consisted of 39 participants, the data from three participants were excluded from the analysis due to a significant amount of missing information.

3.7.1.6 Activity evaluation form

An activity evaluation form was attached to the end of every STEAM activity sheet (Appendix D). It included six open-ended questions investigating each group's individual experiences, thoughts, and suggestions about each STEAM activity. Science teachers were encouraged to answer these open-ended questions in groups rather than on their own after completing each activity.

The open-ended questions in activity evolution form were written by the researcher and a graduate student in collaboration with a subject matter. The researcher first wrote many questions and then sent those questions to a university professor for feedback. The questions were revised based on the instructor's comments and suggestions. After that, two graduate students reviewed the revised question for the meaning issues and grammatical structure.

3.7.1.7 Post-evaluation form

The researcher designed a survey composed of 74 closed-ended and nine open-ended questions in collaboration with a graduate student. The survey evaluated the teachers' experiences and perceptions of the processes they went through throughout the camp. Two instructors who have conducted research studies on interdisciplinary approaches checked the survey questions for validity issues. After performing two iterations involving revising or rewriting the survey questions based on the experts' feedback, the survey was finalized (Appendix C). Participants' answers to closed-ended questions were measured on a 7-point Likert-type scale ranging from '1' = 'strongly disagree' and '7' = 'strongly agree.' A large point scale (1-7) is intentionally utilized to get more variation in response and refrain participants from selecting the points that do not fit their choices.

The survey questions were divided into eleven categories: contributions and benefits, enjoyment and satisfaction, time allocation, quality and quantity of materials, knowledge integration and application, support and assisting, knowledge and skill development in multiple disciplines, prospective planning, learning gain, nurturing of creativity, challenges and difficulties, and environment and location.

The survey items were developed to capture teachers' first-hand experience of the activities in terms of several dimensions in the first and second camp. Several strategies were used by the researcher to establish the reliability and validity of the survey items. First, the researcher wrote a bunch of closed-ended questions according to research needs and then two doctoral students inspected them in terms of language, meaning, clarity, appropriateness, and understandability. Items with comparable meanings were combined, and those with unclear or confusing meanings were either altered or rewritten. Following that, two experts reviewed the revised survey items to determine their suitability for measuring teachers' camp experiences. The survey items were finalized after being revised in response to feedback from two experts.

While analyzing teachers' responses to the questions, it was revealed that, like the pre-evaluation form, eight science teachers either did not answer the questions in the post-evaluation form or left the form incomplete. As a result**,** the total number of participants who filled out the survey was thirty-one.

3.7.2 Data collection process

This section was devoted to the detailed description of the qualitative and quantitative data collection processes. Each of the collected data types and the procedures followed are reported as follows.

3.7.3 Interviewing

The semi-structured interviews were conducted with six teachers from the first camp (3 men, 3 women) and four teachers from the second camp (2 women, 2 men). The researcher himself carried out all the interviews in a meeting room where the camp was being implemented. The interviews took about 23 minutes to 53 minutes, with a median of 35 minutes.

The interviews, which were started upon the camp's completion, were conducted in line with the suggested interview guide (Creswell, 2012). The following is the detailed information on the steps that guided the interview process of the current study.

Interviewees were identified: Purposive sampling method was utilized to select the potential interviewees, science teachers, for the study. Patton (2002) cites purposive sampling as information-rich cases conceived of as having a high potential to provide a detailed description of what is being inquired for the study's purpose. The subjects' primary inclusion criteria were as follows: science teachers (1) who had been actively involved in working through a series of STEAM activities and (2) interested in applying those activities in school with their students were selected for face-to-face interviews.

The type of interview to be used was determined: A one-on-one unstructured interview strategy was adopted to have interviewees answer each research question. The semi-structured interview was chosen because it provides an informal environment where respondents can freely talk about their activity design experiences.

The questions and responses were audiotaped during the interview: A smartphone was used to record all interviews. Once an interview was finished, an anonymous name was given to the interview audio file. A copy of the audio file from a smartphone was then transferred to both a desktop computer and a data storage device. The same procedures were applied for all the interview audio files followed.

Brief notes were taken during the interview: While the interviewee answered the interview questions, the interviewer took some quick notes, especially during the preliminary talks. Those notes, comprised of words and short sentences, were employed in follow-up interviews to get more information from the interviewees.

A quiet and suitable place for conducting the interview was located: A small meeting room was prepared in advance to make sure that the interviewing was safe, comfortable, and away from distractions and interventions. Before starting each interview, the researcher stuck a note on the door of the meeting room so that nobody could make interruptions while the interviewing was in progress.

Consent was obtained from the interviewee to participate in the study: The interview form, as mentioned previously, consisted of two parts: introduction and questions. The introduction part served as a consent form through which information related to the study's purpose, privacy considerations, and the plans for using interview results were conveyed to the participants. Before starting the interview, the researcher delivered consent to the participants. The talks were immediately begun right after the participants read the informed consent and accepted it.

A flexible plan was established: During the interview, the researcher adhered to the questions and tried to keep interviewing flexible at the same time so that the interviewee might not feel forced to speak only about what was being asked. Moreover, the researcher attentively followed the interviewees' conversation, tried to keep eye contact with them, and used appropriate facial expressions to communicate.

Probes were used to obtain additional information: Probes supported interview questions to elicit more information from interviewees. Probes are described as improvised questions in interviews that could yield in-depth responses depending upon the interviewee's answer (Fraenkel et al., 2012). More specifically, the interviewer may probe the respondents to seek clarification, provide more explanation, and get new examples for the subject being investigated (Bogdan & Biklen, 2007). During the interviews, the researcher first encouraged participants to talk about their experiences, perceptions, opinions, feelings, and knowledge related to the STEAM activities and then probed them more deeply into these areas.

The interviewer was courteous and professional when the interview was over: Once the interview was over, the researcher thanked the participants and assured them that their responses would be confidential. In addition to that, the interviewees were asked to be informed regarding the results of the study.

3.8 Data analysis techniques

Dealing with multiple forms of data (e.g., interviews, surveys, artifacts) and drawing meaningful representations from it could be a challenging and time-requiring process for a qualitative researcher. The authors have developed some analysis strategies to make this process more efficient and well-organized. In this study, data analysis was performed based on the steps suggested by two leading authors (Bogdan & Biklen, 2007; Creswell, 2013). The analysis steps presented by Bogdan and Biklen (2007) start with (1) working with the data, proceed with (2) organizing them, continue with (3) breaking them into manageable units, follow with (4) coding them, and finalize with (5) synthesizing them and (6) searching for patterns. Creswell (2013) presented similar steps, starting with (1) preparing and organizing data, proceed with (2) reducing the data into themes through a process of coding, continue with (3) condensing the codes, and end with (4) representing the data. At first glance, the steps specified above in numerical order might seem to be isolated and independent from one another. However, each step depends on the preceding one, like a spiral of activities to a certain extent.

Mixing of the data analysis strategies mentioned above was taken as guidance and allowed to steer the coding data process in this current study. Specifically, the following approaches were applied during the overall data analysis process. The initial coding process was begun with coding one of the transcribed interview data. In this process, each sentence expressed by the participant was iteratively reviewed to detect and fish out a word, text segment, or a sentence that indicates a meaningful concept. Then, a tentative label was assigned to that concept. The label was either generated by the researcher or directly taken from the transcript to guarantee that the most suitable label represented the concept. As analysis proceeded, the new concepts were discovered, and the new labels were assigned to them. However, when a concept that had the same or similar meaning to the preceding one was explored, the corresponding text segment was put under the previously assigned label, which allowed the researcher to develop categories and accumulate concepts with similar properties and dimensions under the same category (Corbin & Strauss, 2008).

Once the initial coding process was finished for the first interview transcript, the second coding process was initiated. All the codes explored were first reviewed and then grouped into broader categories or themes based on the commonalities. During that process, the concepts that were not fitted to any class or remained isolated from other concepts were considered in further data analysis. In this way, the process of coding the first interview transcript culminated with a list of tentative codes, also called “lean coding” (Creswell, 2013). The other remaining interview transcripts were reviewed mostly based on the codes included in this list. As a result, as the coding proceeded, the list evolved by adding new and different categories and concepts.

The final stage was to draw meaningful interpretations out of the codes and represent them in textual, tabular, or figure form. To do this, the researcher tried to make sense of the data by interpreting it within his personal views and making meaningful connections across the codes.

The qualitative data analysis techniques described above were used to analyze the data from in-depth interviews and the data stemming from open-ended questions, observations, and artifacts. The researcher independently coded and analyzed data from interviews, observations, and artifacts. After that, he combined and merged the analytic categories drawn from each analysis. Some of the analytical categories were then adjusted and revised based on the entire data corpus.

The Statistical Package for Social Sciences (SPSS) was utilized for quantitative data analysis. The descriptive statistics, including frequency distribution, the percentage, mean, and standard deviation, were used to analyze the survey and questionnaire data.

3.9 Validation of the study

Several perspectives have been developed to deal with threats to qualitative research's validity and reliability issues. In other words, the researchers’ different understandings of reality and philosophical perspectives makes them develop a different conception of how to establish the authenticity and trustworthiness of the study (Merriam, 2009). In essence, it could be asserted that the concept of “validity” corresponds to the “accuracy” of the findings in qualitative research (Creswell, 2013). This study’s validation techniques consisted of trustworthiness and authenticity, reliability, intercoder reliability, prolonged engagement, persistent observation, triangulation, audit trail, thick description, and peer debriefing.

3.9.1 Trustworthiness and authenticity

A variety of terms or concepts have been constructed in various research studies to deal with validity matters. Determining the study's credibility has become an important common goal for all researchers (Creswell & Miller, 2000). In their perspective on the validity issue, Lincoln and Guba (1985) proposed trustworthiness and authenticity to handle the concerns that might come out to question the extent to which the study is trustworthy and authentic. The current study adhered to Lincoln and Guba (1985) on validity criteria and endeavored to establish that the results drawn from the study have sufficient quality of being regarded by readers as authentic and trustworthy. The reason is that the researcher has to convince audiences and readers that their findings are reliable, accurate, and plausible and can be trusted without any doubt (Merriam, 2009).

3.9.2 Reliability

Reliability refers to the study findings' consistency or study approaches across different researchers and different projects. However, as stated by Gibbs (2007), individual researchers might have difficulty establishing the consistency of the process they follow in their qualitative study with other research studies. Therefore, Gibbs (2007) provided the following tips (or strategies) on making the analysis reliable and self-consistent. These reliability strategies served as a guide during the investigation of qualitative data in this study.

- Transcription checking – making sure that the transcription is deprived of apparent mistakes.

- Definitional drift in coding – checking the data with codes regularly during the coding process to avoid drift in the definition of codes and a shift in the codes' meaning.
- Code cross-checking (also known as intercoder agreement) – comparing the coding results of independent researchers who work on the same dataset.

3.9.3 Intercoder agreement

The intercoder agreement is a term with similar meaning to code cross-checking and inter-rater reliability to describe the reliability process in qualitative research. It involves analyzing transcribed data by multiple independent coders and mainly focuses on detecting the consistency of results or codes with the data (Creswell, 2013; Marshall & Rossman, 2011). Despite the standard views that intercoder agreement can serve as an effective practice to ensure the stability of the qualitative study results, some authors criticize it because of depending heavily on human behavior, which is dynamic and unpredictable (Merriam, 2009). Therefore, it would be more useful to judge the study's reliability based on the consistent definitions instead of the same meanings given by independent coders on the same part of the written content.

In the current study, two doctoral candidates, who pursued their Ph.D. in computer education and instructional technology and previously engaged in coding the transcribed qualitative data, served as an intercoder or rater. Both of them were on the verge of defending their dissertations using qualitative research. The following were the procedures followed before, during, and after the process of coding data:

- Each encoder was informed about the study's fundamental elements, including research questions, the purpose, sample, the method, and the way data collection and research was performed.

- After completing coding, the transcription for patterns, the researcher showed two intercoders how he coded one of the transcribed interview data and the terms he used to define the concepts.
- Each intercoder independently analyzed and coded the transcription to generate their codes applying the same coding scheme. The researcher helped the intercoder clarify the parts on which they got stuck.
- Upon completing coding, the intercoder came together with the researcher to compare their results to detect and note both consistent and inconsistent codes. The compatible codes referred to the codes with similar meanings or in agreement, whereas the incompatible codes referred to the codes in disagreement. During a small discussion on inconsistent codes, every rater made his remark to explain why he gave different codes to the same text. The final decision on the conflicting codes was made after each party reached a joint agreement.
- The number of codes in agreement and disagreement was counted to calculate intercoder reliability using the formula suggested by (Miles & Huberman, 1994). According to the procedure, the intercoder reliability score (x) is equal to the number of agreement (y) divided by the sum of the number of agreement (y) and disagreement (z). Miles and Huberman (1994) noted that a score above the threshold value of .80 indicates good reliability.

The intercoder reliability scores calculated for the first and second interrater were 85 and 90, respectively. Both scores were higher than 80, which is acceptable, according to Miles and Huberman (1994).

3.9.4 Prolonged engagement and persistent observation

Prolonged engagement and persistent observation are the validation strategies that emphasize the necessity of a researcher's prolonged exposure to the research setting. Spending more time with participants and observe them in an activity setting allows the researcher to build trust and rapport with them and make salient decisions about the study (Creswell, 2013; Creswell & Miller, 2000). Also, it is asserted that the more interaction researchers have with data sources, the more accurate the study findings would be (Creswell, 2009). Due to this study's method, the researcher was naturally immersed in every action taking place during each study phase. In other words, he prepared all the STEAM activities along with the accompanying documents. Moreover, he was actively involved in implementing STEAM activities together with the participants. For that reason, the researcher's long-term contact with participants and complete engagement in the study setting over a prolonged period is a clear indication of the fact that he established engagement and persistent observation.

3.9.5 Triangulation

In qualitative inquiry, it is argued that the information from a single source may not be adequate to shed light on the phenomenon being investigated. Instead, the authors call for using and combining various methods or data sources for the study to result in rich, robust, and comprehensive results, which is called triangulation (Creswell & Miller, 2000; Patton, 2002). In this study, the data were collected from multiple and different information sources, including participant observations, interviews, surveys, and e-textile designs. Furthermore, multiple intercoder engaged in coding the transcriptions along with the researcher. Consequently, it could be concluded that the strength of the study results was ensured through triangulation.

3.9.6 Audit trail

The audit trail refers to full documentation of decisions, actions, and activities that took place and were undertaken within the study's scope to answer the research questions. An audit takes place when the researcher gives a detailed account of collecting data, assigning and generating codes, and making decisions throughout the inquiry (Merriam, 2009). In other words, an audit trail is established when "researchers provide clear documentation of all research decisions and activities including keeping a research log of all activities, a data collection chronology and data analysis procedures" (Creswell & Miller, 2000, p. 28). In this current study, the audit trail was established in each study phase through the report and documentation of data collection processes, data analysis procedures, and how the STEAM activities were developed and implemented.

3.9.7 Thick description

Thick Description is proposed as a means of strengthening the study results. It is stated that the study results become more realistic and more prosperous when the investigator describes the study settings in detail (Creswell, 2013). According to Creswell and Miller (2000), the study's events should be described in such an elaborative way that it could evoke the feeling that the readers have experienced it before. To make sure the thick description is established throughout this study, the researcher reported and described all the events, steps followed, procedures and methods applied, and the decision made in the study setting.

3.9.8 Peer debriefing

Peer Debriefing is a validation strategy used during the whole research process to establish the research's credibility. It requires the necessity of inspecting the data and study process by a rational and impartial person who is knowledgeable about the entire study (Creswell & Miller, 2000). In peer debriefing, the researcher must collaborate closely with the external reviewer to critically review the implementation and evolution of the study methods. In this current study, the following peer debriefing methods were conducted. The thesis committee members periodically checked the study process and provided their thoughts, critiques, feedback, opinions, and suggestions regarding the study's methods. Besides, the study's implementation and the techniques and strategies applied were performed in collaboration with the thesis adviser. Moreover, the researcher occasionally consulted with his colleagues who had been involved in conducting similar research methodologies.

3.9.9 Ethical considerations

The ethical concerns which were considered in this study included approval from the ethics committee, anonymity, confidentiality, and informed consent. First of all, permission to conduct the research was obtained from METU Human Subjects Ethics Committee (see Appendix F). Secondly, the consent form informed all of the science teachers who voluntarily participated in every stage of the study and ensured that their identities and the information they shared would be anonymous confidential. Thirdly, all of the participants were approached and treated with respect in every stage of the study.

As shown in Table 3.10 below, the researcher created a list of pseudo-names and used them alongside the quotes to assure the participants' anonymity and confidentiality while presenting the study findings. In the results chapter, the themes that emerged were presented along with the relevant quotes extracted from the transcripts. Since the whole corpus of data were stemmed from different data forms, different pseudo-names were used for each data source.

Table 3.10 A list of pseudo-names used alongside the quotes

Pseudo-name	Description	Instrument
FC_INT	First camp interview	Interview protocol
FC_PRE_OE	First camp pre-open-ended question	Pre-evaluation form
FC_GR_OE	First camp group open-ended question	Activity evaluation form
FC_POST_OE	First camp post-open-ended question	Post-evaluation form
SC_INT	Second camp interview	Interview protocol
SC_PRE_OE	Second camp pre-open-ended question	Pre-evaluation form
SC_GR_OE	Second camp group open-ended question	Activity evaluation form
SC_POST_OE	Second camp post-open-ended question	Post-evaluation form

CHAPTER 4

RESULTS

The results chapter covers the current study findings drawn from the analysis of qualitative and quantitative data collected in different phases of the study with different data collection tools. The semi-structured interviews provided the core data, triangulated with observations, pre-and-post open-ended questions, survey data, and teachers' STEAM artifacts. The results of qualitative and quantitative data were merged and reported together.

While the qualitative part reports the emerged themes and their subthemes, the quantitative part presents the descriptive statistics, including mean, mode, and frequency. The relevant tables and figures accompanied qualitative and quantitative findings to make the results clear and understandable. In the final part of this chapter, the study findings—obtained from the interviews, open-ended questions, observations, experiences, and camp assessment forms—were condensed into a set of design principles.

In this section, a broad spectrum of science teachers' experiences and opinions regarding different parts of STEAM activities are reported. Science teachers who had an opportunity to engage with hands-on STEAM activities presented their activity experiences and expressed their opinions about applying, implementing, and integrating STEAM activities.

To sum up, the systematic analysis of data gathered from different sources culminated with five main themes. The coding tree, including themes and subthemes, is shown in Figure 4.8. The emerged themes are categorized under the name of (1) perceived benefits, (2) experiences and opinions, (3), transfer of knowledge and experiences (4) challenges, and (5) design principles. The main themes and related sub-themes are reported, together with some sample quotations from both the interviews and the answers to the open-ended questions, and descriptive statistics. Before presenting the study results under main themes, an overview of the study is provided to better understand the design and development process of STEAM activities.

4.1 Overview of the results from Cycle 1 to Cycle 3

4.1.1 Cycle 1

Cycle 1 of the research involved reviewing pertinent e-textile studies and drawing inspiration from the authors' use of design examples (Buechley, 2006; Fields et al., 2018, 2019, 2021; Kafai, et al., 2014; Lindberg et al., 2020; Litts et al., 2017; Peppler & Glosson, 2013). To determine the types and qualities of the projects to be utilized in pilot trials, the researcher closely collaborated with a university teacher, a doctoral student from the technology education field, and a university instructor, two doctoral students from the science education field.

The first version of activities did not have clear structure but rather consisted of several sections including information about the activity. The analysis of the data collected from Cycle 1 showed that the activity sheet should be as simple as possible so that teachers do not get distracted and lose their way by being exposed to too many texts showing them how to design activities.

Besides, the analysis result indicated that activities should be sewn and crafted in line with some legitimate and practical stages. More specifically, it was found that activity design process would be more systematical and organized if participants follow some useful design stages. The reason to adopt stages of the design thinking process was to provide a structured approach for solving problems in a user-centered way. We also conceptualized that by going through each stage, the teachers would be able to develop a deeper understanding of the design needs and come up with more innovative solutions. Additionally, it would allow teams to iterate and improve their ideas based on feedback from testing.

In Cycle 1, the activity sheet provided various drawings to show how to assemble and connect the circuit components. The results showed that instead of using many drawings to show the connection of each circuit component, it would be more useful to provide only the circuit diagram.

The activities in Cycle 1 did not include activity scenario. Cycle 1 results indicated that the activities should be built around problem-based scenarios so that teachers find them meaningful enough to put effort into their designs. Therefore, a problem-based scenario was developed for each activity.

It was found that letting teachers to write code to control circuit components like LEDs and sensors attached to the activity circuit took lots of time. It was thought that read-made code can save time for the project groups using it and can serve as a starting point for their projects. Furthermore, because teachers lacked programming knowledge, they found it challenging to write a code segment. That is why, the researcher wrote and prepared the codes for the activities that required code writing in advance.

Doing activities in a limited area and on small tables refrained teachers or students from moving smoothly and comfortably while working on their projects. Teachers considered rectangular classroom tables and chairs unsuitable for the project construction. Instead, they stated that there should be a large and wide place for activities' implementation.

4.1.2 Cycle 2

Cycle 2 results showed that there should be additional wearable e-textile technologies, specifically Lilypad Arduino. Besides, teachers asked for the demonstration of several sample designs for each activity so that they could be inspired and develop better and creative ideas about their design.

Three activity scenarios were found by teachers to be confusing and lacking in important problem-identification details. Those scenarios were either revised or rewritten again. Additionally, certain grammatical and punctuation errors found by teachers in activity sheets were fixed.

In Cycle 2, teachers had difficulties sewing stitches on thick materials (3mm). Besides, they found thin textile material quite challenging to sew with conductive thread. Therefore, the amount of thick and thin materials, specifically felt, was decreased in Cycle 3.

It was thought that a detailed activity sheet would be enough for teachers to understand the projects clearly. The results of Cycle 2 showed that the activity should be introduced first so that teachers can ask any questions about any activity part that may be needed more clarification.

Cycle 2 results indicated that teachers tend to ask more assistance during the first activities and their requests for assistance decrease in times. Therefore, in Cycle 3, the number of individuals with experience of STEAM projects using e-textiles was increased.

Although read-made code can save time for the project groups using it and can serve as a starting point for their projects, providing ready-made code might not replace the need for learning and understanding the underlying concepts and principles of e-textiles-supported STEAM projects. Therefore, the project groups were assigned a new task that required them to edit and remix the code provided for each activity.

A design is a blueprint for how to construct a structure. A design sketch is a graphical representation of a design plan that has been sketched. In Cycle 1, project groups crafted and sewed their projects without drawing its sketch or outline. It was discovered that the final designs of teachers' projects significantly diverged from the initial designs they had outlined and intended at the outset. Top keep project groups stick to the initial design they envisioned; a design sketch form was attached to each activity sheet which allowed them to draw and visualize the spatial arrangements of the project design.

4.1.3 Cycle 3

Cycle 3 results showed that male dominant groups outperformed female dominant groups in terms of project functionality but failed in aesthetics. Therefore, forming project groups that include members of both sexes would be beneficial for both male and female participants.

The analysis of data from Cycle 3 revealed that in e-textiles-supported STEAM project design, it is essential to understand the properties and behavior of different types of fabrics, fibers, and yarns. Besides, it is important to have basic technological knowledge or experience regarding the application of electronic systems and devices, including sensors, actuators, and microcontrollers. As a result, project groups should include middle school science teachers as well as teachers from the fields of technology and design and fine arts.

In Cycle 2, project groups were encouraged to follow design thinking stages while personalizing their projects not only by choosing different felt colors, but also by incorporating different LED colors, stitches, decorations, LED placement, and the construction of various hand-made icons. Yet, during the design process, they diverged from design thinking stages and kept using their eclectic stages. Therefore, activity design process was divided into tasks which were design thinking stages, and the activity sheets were redesigned accordingly.

In Cycle 2, the decision to form project groups was left to teachers. In other words, in each activity, teachers chose their project group members. However, the study's findings revealed that teachers tended to form male- or female-dominated groups, or groups with teachers with whom they felt they could get along. In Cycle 2, teachers were encouraged to form mixed-gender groups.

4.2 Perceived benefits of designing and sewing STEAM projects

Under this theme, the findings are reported on the perceived benefits of STEAM activities. Perceived benefits theme composes of two sub-themes: the classroom as an ergonomic and democratic learning environment and development of knowledge and skills.

4.2.1 The classroom as an ergonomic and democratic learning environment

The science teachers expressed their views and opinions about STEAM activities' positive effects on classroom climate and learning settings. One of the second camp teachers said in the interviews that hands-on activities created a warm learning environment where they (or students) could find a chance of developing the feeling of respecting one another. STEAM activities' learning space might be capable of nurturing a sense of respect and the other emotional and humanistic attitudes or behaviors. The reason is that STEAM activities bring learners with different skills and behaviors together into a new community in which they naturally get into learning to interact with other people, respect their ideas and the way they do activities, and share responsibilities.

> *[SC_INT-1]: In the camp, you can share ideas about what is what and how it is what. I think there can occur a pleasant and warm environment. A good interaction can take place with your group friends and friends at the next table. You can learn to show respect while sharing the stuff, which is very important for the child. Respecting each other and saying the phrase "may I take it?" is quite important. You can benefit from it necessarily. A beautiful environment is formed there.*

> *[SC_INT-1]:Kampta ne nedir nasıldır gibi konularda fikir paylaşımı yapabiliyorsun. Ortamda güzel bir sıcaklık oluşabiliyor bence. Hem grup arkadaşlarınla hem de yan masadaki arkadaşlarla güzel bir etkileşim olabiliyor. Malzeme paylaşırken saygıyı öğrenebiliyorsun. Çocuk için bu çok önemli. Birbirlerine*

saygı göstermek "alabilir miyim" demek çok önemli. Sen de ister istemez bundan faydalanabiliyorsun. Güzel bir ortam oluşuyor.

The findings indicated that the contributions of STEAM activities are not only limited to the classroom climate. It also brings about some benefits to the learning space. In the current study, the learning space is an environment where teachers gather and engage in crafting their STEAM designs using e-textile technologies. All ten teachers in the first and second camps emphasized in the interviews that the STEAM camp provided both ergonomic and democratic learning space where they could easily find the tools, freely speak and express their opinions, and use any materials they wanted. The presented findings were supported by survey results demonstrating that a total of 74.2% of the teachers disagreed or strongly disagreed that "It was hard to find the materials that I need for the activity designs" (see Table 4.2). However, when it comes to the students, teachers warned that some students might try to exert dominance over the other students, thereby disrupting the democratic learning environment.

[FC_INT-4]: We could easily access the material, and the layout of the tables was adorable. The camp environment was ergonomic. You need a table where you can have everything and have access to it. The camp atmosphere was a little bit messier, because the order sometimes gets distorted, which will be the same or even worse in schools.

[FC_INT-4]: Malzemelere kolaylıkla erişebildik ve masalardaki düzen güzeldi. Kamp ortami ergonomikti. Her şeyin elinizde olabileceği ve ulaşabileceğiniz bir masanın olması lazım. Ortalık biraz karışmıştı çünkü düzen bazen bozuluyor ki okullarda da aynı şey olacak hatta daha beteri olacaktır.

[FC_INT-1]: I would say that it provides a democratic learning environment. No problem happens if the people in the groups do not have adaptation problems. The teachers here did not have such a problem, but the students could say, for example, "I do not work with Ayşe," "I do not form a group with Ali." If this is not the case, it is not a problem.

[FC_INT-1]: Demokratik bir öğrenme ortamı sağladığını söyleyebilirim. Eğer gruplardaki kişiler uyum problemi yaşamıyorsa hiçbir sıkıntı olmuyor. Buradaki öğretmenlerde öyle bir sorun olmadı ama çocuklar "Ben Ayşe ile çalışmam", "Ben

Ali ile grup olmam" diyebiliyor. Eğer böyle bir durum söz konusu değilse öyle bir sorun olmaz.

[SC_INT-3]: The camp provides a democratic environment because the materials were shared equally. Students can make whatever they think. We do not limit the student's creativity, so he can bring out any product he wants.

[SC_INT-3]: Kampta herkese eşit malzeme verildiği için demokratik bir ortam oluşuyor. Öğrenciler fikirlerini özgürce yapabilir. [Öğrencinin] yaratıcılığını sınırlamıyoruz, bu yüzden istediği ürünü ortaya çıkarabilir.

4.2.2 Development of knowledge and skills

Science teachers were asked to express what contributions STEAM training camp could have on students when the same activities are applied in the school. The findings revealed that active involvement in STEAM activities could result in the acquisition of a wide variety of skills and knowledge from different subjects. The versatile skills teachers pinpointed range from affective skills, cognitive skills, collaborative learning skills, and psychomotor skills to authentic learning skills, creativity skills, and a grasp of skills in fundamentals subjects. Each of these skills is explained below in the mentioned order.

Affective and self-efficacy skills

The STEAM activities' potential effects on gaining affective skills are reflected in science teachers' responses to interview questions. Three of the teachers in the first camp and one of the teachers in the second camp pointed out the many capabilities of the STEAM activities such as boosting motivation, increasing self-confidence, taking pleasure at making something, promoting a feeling of sharing something, crafting a design together, and establishing a trusting and respecting climate. They also added that the activities could help raise positive attitudes towards science and make learners aware of their existing skills in multiple fields.

[FC_INT-3]: Now, this question is posed to a person whose art and aesthetic skills are weak. I think that this program has

contributed to us. It has shown to us that we have developed a skill and talent.

[FC_INT-3]: Şimdi sanat yönü, estetik yönü zayıf olan bir kişiye bu soru yöneltiliyor. Ben de şunu düşünüyorum: bu program bizde bir şeyleri geliştirdi, bir becerimizin geliştiğini ve yeteneğimizin olduğunu gösterdi.

[FC_INT-4]: Not only will the student do it himself but also he/she will learn while doing it, exhibit his/her project design, and in turn, will be happy. I felt thrilled after the first day. I said to myself that I could do it and learn. I felt better. The first day's activities were fortunately so easy that it comforted me.

[FC_INT-4]: Öğrenci hem kendisi yapacak hem de yaparken öğrenecek, ürününü sergileyecek ve mutlu olacak. Ben ilk günden sonra çok mutlu olduğumu hissettim. Kendi kendime ben de yapabiliyor ve öğrenebiliyormuşum dedim. Kendimi daha iyi hissettim. İlk günkü etkinlikler iyi ki o kadar kolaydı çünkü bu beni rahatlattı.

[FC_INT-6]: The STEAM activities improve student's positive attitude towards science courses.

[FC_INT-6]: [Etkinlikler öğrencinin] fen dersine karşı olumlu tutumunu geliştirir.

Besides, teachers thought that when students become involved in making STEAM activities, they would develop a sense of caring and respect for their peers and the other students and establish a sense of sharing. Based on the results, it might not be wrong to assert that STEAM camp can develop the aforementioned affective skills because it provides a real-life setting where teachers or students in groups develop an innovative design solution to the problem from scratch. To accomplish this, they somehow have to handle design works with care, respect other participants' ideas and efforts even if they sound wrong, and share their experiences, knowledge, and even materials with one another.

[SC_INT-3]: It increases the feeling of doing and sharing something.

[SC_INT-3]: Birlikte bir şey yapabilme ve paylaşma duygusunu artırıyor.

Authentic learning skills

Authentic learning skills are the skills that can be acquired through connecting and transferring learning to real-life activities. All ten of the teachers in both the first and second camps expressed that STEAM activities encouraged learning by exploring and making. The same result was also found in teachers' responses to the group-open-ended questions. Two first camp teachers and a second camp teacher stated that STEAM activities provided ample opportunities for students to learn in making and crafting e-textile projects. Teachers also described that while doing STEAM projects, students would experience failures and successes and, in turn, learn how to do something right, explore different ideas and solutions to the problems, and make connections across various components.

> *[SC_INT-3]: I think the activities we have engaged in support learning by doing and exploring.*
>
> *[SC_INT-3]: Yaptığımız etkinliklerin yaparak ve keşfederek öğrenmeyi desteklediğini düşünüyorum.*
>
> *[FC_INT-5]: When we combine seven activities, a program is formed. These activities also support learning by doing and exploring.*
>
> *[FC_INT-5]: Bizim yedi etkinliği bir araya getirdiğimizde bir program oluşuyor aslında. Bu etkinlikler de yaparak ve keşfederek öğrenmeyi destekler.*

Learning is likely to be meaningful and transferable when constructed through making in interdisciplinary activities. One of the first and second camp teachers stated in interviews that what had been experienced and gained in the camp could be transferred to the everyday setting and activities. They also added that these interdisciplinary activities would help students connect their learnings and experiences to real-life situations.

> *[SC_INT-4]: The activities primarily make information meaningful. There is always a question: where will we use it in the future? You can give this as an example in class. For instance, I can use it here, and you can use it that way. I think that these activities are utterly beneficial because it relates abstract information to everyday life.*

[SC_INT-4]: [Etkinlikler] öncelikle bilgiyi anlamlandırıyor. Hep şu soru vardır. biz bunu ilerde nerde kullanacağız. Yani bunun birebir örneğini derste veriyorsun, işte ben bunu şurada kullanabiliyorum, siz de bu şekilde kullanabilirsiniz diye. [Etkinliklerin] günlük hayatla bilgiyi ilişkilendirdiği için kesinlikle faydalı olduğunu düşünüyorum.

[FC_INT-6]: Through these activities, students learn to reflect their knowledge to daily life. They do not memorize information, but they transfer them to everyday life.

[FC_INT-6]: Öğrenciler bu etkinlikler sayesinde bilgilerini günlük hayata yansıtmasını öğrenir. Bilgileri sadece ezberlemez onları günlük hayata da aktarır.

Cognitive skills

The result showed that STEAM activities played an important role in helping learners build cognitive skills ranging from problem-solving and professional knowledge to analytical and critical thinking skills. Four of the teachers in both the first and the second camp expressed in the interviews that STEAM activities developed problem-solving skills. The same result was observed in the group's statements in the open-ended questions by one of the first camp teachers and all seven teachers in the second camp. Moreover, teachers believed that if students get engaged in making and crafting a STEAM design, there is a high possibility that their problem-solving skills would be improved.

[FC_INT-6]: Of course, there is a problem in the activity scenario, and the student reads and finds a solution to it, which develops students' creativity and problem-solving ability.

[FC_INT-6]: Tabi ki senaryoda bir problem var ve öğrenci o senaryoyu okuyup ona bir çözüm yolu buluyor. Bu da yaratıcılığını geliştirir ve problem çözme yeteneğini geliştirir.

[SC_GR_OE-7]: I believe that such STEAM activities will undoubtedly develop the students' problem-solving abilities.

[SC_GR_OE-7]: Bu etkinlikler aracılığı ile öğrencilerin problem çözme becerisinin kesinlikle gelişeceğini düşünüyorum.

[SC_INT-4]:I can tell this for sure: These activities higher the problem-solving abilities

[SC_INT-4]:Şunu kesinlikle söyleyebilirim: Bu etkinlikler problem çözme yeteneğini geliştiriyor.

Two of the teachers' responses to the interviews and one of the teacher's responses to the group open-ended questions in the first camp highlighted the idea that STEAM activities stimulated critical thinking. Teachers believed that attending the training camp would inevitably result in the development of critical thinking skills.

[FC_INT-5]: Besides, you are constantly arguing with others in the camp, which improves critical thinking.

[FC_INT-5]: Ayrıca, kampta sürekli tartışıyorsunuz bu da eleştirel düşünceyi geliştiriyor.

It is a well-known idea that students may not learn and understand abstract concepts readily unless associated with other meaningful pieces of information. The results showed that STEAM activities could ease the process of learning the concepts that are difficult to understand and comprehend the current pedagogies in schools. Two of the first camp teachers expressed in the interviews that STEAM activities turned abstract ideas into concrete experiences, which were relatively more meaningful and easier to understand.

[FC_INT-5]: As I said, students can see abstract things more concretely. For example, I had no knowledge of the Arduino program before the camp, but now I know the basics of Arduino, and I can write a very simple code.

[FC_INT-5]: Dediğim gibi öğrenciler soyut düşünmesi gereken şeyleri daha somut görebilir. Mesela benim Arduino programı ile ilgili hiçbir bilgim yoktu ama şimdi Arduino ile ilgili fikir sahibi oldum, çok basit de olsa bir şeyleri artık kodlayabilirim.

[FC_INT-2]: Students usually think that where this will help us in our work. There are no such things here. For example, motion-sensing sensors are used to open and close doors; we could see it in our environment. There is also a concretization here.

[FC_INT-2]: Çocuklarda genelde şu vardır; bu bizim nerede işimize yarayacak. Burada o yok. Mesela hareket sensörü, açılıp kapanan kapılarda kullanılıyor, gerçeğini çevremizde görüyoruz. Burada bir somutlaştırma var.

Collaborative learning skills

Interactions and collaborations within and between groups are naturally an inevitable and integral part of the STEAM activities. It is challenging to conceive these activities without interactions and collaborations. A similar view was evidenced during both camps. It was observed that science teachers did not only get into talking the project design matters over with their peers, but they also had small discussions and conversations with other groups to either seek a solution or take a piece of advice from them. Furthermore, among the skills associated with STEAM activities, teachers mostly highlighted collaborative learning skills. All ten of the teachers interviewed in both the first and second camp stated that the interactions taking place during the STEAM activities nurtured collaborative learning skills. The same result also came from teachers' responses to the group open-ended questions. Four of the first camp teachers and all seven of the second camp teachers explained that STEAM activities fostered collaborative learning skills. According to the teachers, the STEAM activities created a cooperative and competitive learning community that promoted sharing and exchanging ideas, information, resources, experiences, and problems both within and between groups. Furthermore, they believed that students' collaborative learning skills would develop if they designed these art-focused hands-on activities.

> *[FC_INT-5]: As I said before, active communication is always there during project design creation. You have to collaborate, if not, you will fail, and an unsuccessful product would emerge. Therefore, during the project design, an active discussion is critical because you learn to respect others' views. Thus, the design process is going on a bit feverish, a brainstorm is always taking place there, and you need to convince the other side with your thoughts. At this point, it is imperative to convince the other side or to reach a common conclusion. Therefore, collaborative learning is significant.*

> *[FC_INT-5]: Daha önce de söyledim, sürekli aktif bir iletişim var. İşbirliği yapmak zorundasınız, yapamadığınız zaman başarısız olacaksınız ve bir iş ortaya çıkmayacaktır. O nedenle oradaki aktif tartışma çok önemli çünkü karşıdaki kişinin görüşlerine saygı göstermeyi öğreniyorsunuz. Dolayısıyla o süreç biraz hararetli*

geçiyor, zaten bir beyin fırtınası var ortada ve karşı tarafı düşüncelerinizle ikna etmeniz gerekiyor. Bu noktada karşı tarafı ikna edebilme ya da ortak bir sonuca varılabilme çok önemli. Bu yüzden işbirlikli öğrenme çok önemli.

[SC_INT-3]: Learning together. For example, when we look at a class situation, there are outstanding students, average students, and unintelligent students. Their progress - even one step further- is an improvement for us. In this sense, I think that activities will reduce the gap across students with different intelligent levels. This situation looks like the slow students reach average students, and successful students go a little higher. In this way, I think the classroom will have the same learning environment. In that sense, this will be the most significant contribution to the students.

[SC_INT-3]: Hep birlikte öğrenme. Mesela bir sınıfın durumuna baktığımız zaman orada çok iyi öğrenci, orta öğrenci, ve zayıf öğrenci oluyor. Onların birer adım bile ilerlemeleri bizim için birer kazanımdır. Bu anlamda [etkinliklerin] öğrenciler arasındaki uçurumu azaltacağını düşünüyorum. Çok kötülerin orta seviyeye gelmesi, çok iyilerin biraz daha üstte çıkması gibi. Bu şekilde sınıfın aynı öğrenme ortamına kavuşacağını düşünüyorum. O anlamda öğrencilere en büyük katkısı o olacaktır.

[SC_GR_OE-2]: It certainly highlights and flourishes collaborative learning, art, and creativity skills.

[SC_GR_OE-2]: Kesinlikle işbirlikli öğrenme, sanat ve yaratıcılık becerilerini ön plana çıkarıyor ve geliştiriyor.

To craft a better STEAM design, teachers in teams or individuals involved in various interactions and communications, which in turn helped them develop a set of collaborative skills, including communication and crisis management. One teacher's responses to both interview and group-open-ended questions in the second camp indicated that the active involvement with the STEAM activities brings about the development of communication skills. Furthermore, one teacher's response to the group open-ended questions in the second camp showed that STEAM activities supported crisis management skills. Grasping communication and crisis management skills might be useful and life-saving, mostly when the designers got stuck in the project design and had a short time to proceed.

[SC_INT-2]: I think that these activities will help students learn communication skills.

[SC_INT-2]: [Bu etkinliklerin öğrencilere] iletişim becerilerini kazandıracağını düşünüyorum.

[SC_GR_OE-1]: Interactions within the camp also improve students' communication skills.

[SC_GR_OE-1]: Kamp içindeki etkileşimler [öğrencilerin] iletişimlerini de geliştirir.

[SC_GR_OE-3]: The activities have the quality of supporting the development of students' crisis management skills.

[SC_GR_OE-3]: [Etkinlikler öğrencilerin] kriz yönetimi becerilerini geliştirmeyi destekler nitelikte.

As part of collaborative learning skills, teachers mentioned the skills associated with individual learning and differences. All ten of the teachers in both the first and second camps expressed in the interviews that in addition to the collaborative learning, STEAM activities supported individualized learning or individual differences. Teachers explained that making activities in groups allowed each group member to demonstrate what they were best at and make unique contributions to the collective team effort.

[FC_INT-4]: The activities support individual differences but most largely support collaborative learning. They also reveal individual differences. For example, while one person is drawing, the other person could be sewing. Of course, these activities require group work.

[FC_INT-4]: [Etkinlikler] bireysel farklılıkları destekliyor ama işbirlikli öğrenmeyi daha çok destekliyor. Bireysel farklılıkları da ortaya çıkarıyor. Örneğin birisi çizim yaparken, diğeri dikim yapıyor. Tabiki bu etkinlikler grup çalışması gerektiriyor.

[SC_INT-4]: There is individualized learning out there. We were two people in the group. My groupmate was continuously stopping me while I was sewing the circuits into felt fabric. He was regularly checking polarity to ensure that things were going the right way, from positive to positive and negative to negative. That's how we completed the circuit.

[SC_INT-4]: Burada bireyselleştirilmiş öğrenme kesinlikle var. Biz etkinliği iki kişi yapıyorduk. Grup arkadaşım sürekli sen bir dur ben devre parçalarını bağlarken kendimce onları anlamlandırayım. Artıdan artıya yada eksiden eksiye

gidiyormuyuz diye sürekli bakıyordu. Bu şekilde devreyi tamamlıyorduk.

Creativity skills

Creativity skills could be regarded as one of the significant benefits of STEAM activities. In the context of this study, they refer to all the ingenious acts and practices teachers go through over the design process to make the final project design functionally and aesthetically innovative and original. In the study, analysis of the science teachers' responses to interview, open-ended, and closed-ended questions revealed many shreds of evidence pointing to STEAM activities' positive effect on creative skills. For example, all ten of the teachers in both the first and second camps expressed in the interviews that engaging in STEAM activities developed and stimulated creativity skills.

Additionally, one of the first camp teachers and all seven of the teachers in the second camp stated in the group-open-ended questions that STEAM activities stimulated innovative and authentic ideas. More specifically, science teachers experienced that STEAM activities entailed a lot of creative works and efforts to craft a project design, which enabled them to showcase their creativity and creative thinking skills and stimulate them efficiently. During the five-day-long camp, it was observed that all groups of science teachers had put plenty of hard work and effort into their design and tried to benefit from any ideas and strategies they could get and never ceased to ask for assistance to produce an innovative project design

[FC_INT-2]: I think that the activities improve creativity because it involves creating a design. These activities are not something that can be without design and creativity. Of course, the students will sew the circuit in an original way and decide on their design. This will undoubtedly be like I said. For example, at the last activity of the camp, we created our design plan. We thought about what we should do for the design. That is to say, fabricating something innovative makes you open to new ideas and production.

[FC_INT-2]: Etkinliklerin kesinlikle yaratacılığı geliştirdiğini düşünüyorum. Çünkü işin içinde tasarım var. Tasarım ve yaratıcılık olmadan olacak bir şey değil bu. Tabiki öğrenciler

devreleri özgün bir şekilde kendileri dikecek ve tasarımına kendileri karar verecekler. Bu kesinlikle öyle olacak. Örneğin, son etkinlikte kendimiz bir tasarım ortaya çıkaracağız. Düşünüyoruz ne yapsak diye. Yani bir şey üretmek sizi yeni düşüncelere ve üretime açık hale getiriyor.

[SC_INT-4]: In STEAM activities, the student primarily makes sense of the information. The design part independently requires creativity. So, it allows using science and mathematics at the same time. That is why I think these activities improve creativity.

[SC_INT-4]: Burada öğrenci öncelikle bilgiyi anlamlandırıyor. Tasarım kısmı başlı başına bir yaratıcılık gerektiriyor. Yani feni ve matematiği aynı anda kullanmamızı sağlıyor. Etkinliklerin bu yüzden kesinlikle yaratıcılığı geliştirdiğini düşünüyorum.

[SC_GR_OE-1]: STEAM activities highlight art and creativity skills.

[SC_GR_OE-1]: [STEAM etkinlikleri] sanat ve yaratıcılık becerilerini ön plana çıkartıyor.

Besides, the researcher’s observations of both camps clearly showed that on many occasions when it came to critical decisions on vital design parts, groups of science teachers tried to use their imagination and creative skills to come up with authentic ideas. That is, each group of teachers was expected to produce an untraditional design by using limited number of sewable electronics and as many textiles and crafting materials as they could. Furthermore, teachers thought that the autonomy STEAM activities gave them in their design and crafting of projects provoked them to find the best creative idea they could ever produce.

[FC_INT-5]: Interdisciplinary activities [STEAM] definitely enhance creativity because you’re seeking something different from other designs in this type of activity. You want to make it different from the others. And your brain immediately starts functioning in the background as to what I can do right away.

[FC_INT-5]: Disiplinlerarası etkinlikler [STEAM] yaratıcılığı kesinlikle geliştiriyor çünkü burada diğer tasarımlardan farklı bir şey arıyorsunuz. Diğerlerinden farklı yapayım istiyorsunuz. Ve hemen ne yapabilirim diye beyin çalışmaya başlıyor arka planda.

[SC_INT-1]: I think that interdisciplinary activities [STEAM] reveal and develop creativity. Everything we did was the result brought on our creativity. Although we did not accomplish many

things during the camp, we later sorted them out with my groupmate. However, there was a big impact of creativity out there. You say that a better one can be done in time.

[SC_INT-1]: Disiplinlerarası etkinliklerin [STEAM] yaratıcılığı ortaya çıkardığını ve geliştirdiğini düşünüyorum. Yaptığımız her şey yaratıcılığın ürünü aslında. Birçok şeyi başaramasak da grup arkadaşlarımla sonradan düzelttik ama yaratıcılığın büyük bir etkisi oldu. Zamanla daha iyisi de yapılabilir diyorsunuz.

Besides, the survey data analysis showed that all the teachers thought that STEAM activities were capable of nurturing, eliciting, and supporting creativity and creative thinking skills. It can be seen from the data in Table 4.1 below that 26% and 74% of the science teachers, respectively, agreed and strongly agreed that STEAM activities stimulated them to use their creative skills. Moreover, all the teachers (23% and 77% respectively) agreed and strongly agreed that their creative skills were developed after engaging in STEAM activities in the camp. Furthermore, a total of 96.7% of the teachers agreed or strongly agreed that "Through the camp, I gained insights about how to design a STEAM project creatively." Consequently, all the teachers believed that crafting STEAM projects encouraged them to use, demonstrate, and develop their existing creative abilities and skills.

Table 4.1 Development of knowledge and experiences in multiple fields

Items	*M*	*SD*	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
The camp increased my knowledge and skills in STEAM subjects.	6.74	0.44	-	-	-	-	-	25.81	74.19
The camp benefited me in many ways.	6.74	0.44	-	-	-	-	-	25.81	74.19
The camp contributed to my teaching profession.	6.65	0.49	-	-	-	-	-	35.48	64.52
The camp helped me to learn the concepts of electricity and electrical circuits.	6.42	0.96	-	-	3.23	3.23	3.23	29.03	61.29
The camp helped me to use and develop my artistic skills.	6.45	0.89	-	-	-	3.23	16.13	12.90	67.74
Thanks to the camp, I learned how to design and develop a product by following the design-oriented thinking steps.	6.58	0.67	-	-	-	-	9.68	22.58	67.74
The e-textile activities in the camp would improve students' fine muscle skills.	6.71	0.69	-	-	-	3.23	3.23	12.90	80.65
The camp increased my interest and motivation for STEAM-focused e-textile activities.	6.77	0.43	-	-	-	-	-	22.58	77.42
The activities in the camp encourage me to use my creative skills.	6.74	0.44	-	-	-	-	-	25.81	74.19

Table 4.1 Development of knowledge and experiences in multiple fields (Continued)

Items	*M*	*SD*	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
The activities in the camp developed my creative skills.	6.77	0.43	-	-	-	-	-	22.58	77.42
The activities in the camp allow for interdisciplinary learning.	6.77	0.56	-	-	-	-	6.45	9.68	83.87
The activities in the camp encourage the use of knowledge and skills in STEAM areas.	6.77	0.43	-	-	-	-	-	22.58	77.42
Thanks to the camp, I got an understanding of how STEAM activities should be designed.	6.61	0.67	-	-	-	3.23	-	29.03	67.74
Through the activities in the camp, I improved my knowledge and skills in STEAM fields.	6.71	0.53	-	-	-	-	3.23	22.58	74.19
I learned a lot about electricity concepts in the camp.	6.42	0.67	-	-	-	-	9.68	38.71	51.61
I learned how to code with Arduino in the camp.	5.71	1.22	-	-	6.45	9.68	22.58	29.03	32.26

Grasp of skills in fundamental subjects

STEAM activities are interdisciplinary design tasks developed at the intersection of design and crafting to help individuals demonstrate and gain their competencies in fundamental disciplines, including science, technology, engineering, arts, and mathematics. All ten of the teachers interviewed in the first and second camps expressed that STEAM activities could help teachers and students to use and develop knowledge and skills in multiple areas. More specifically, art, science, and engineering became the featured subjects that teachers had felt their presence in STEAM activities more than the others. Likewise, as displayed in Table 4.1, all the teachers agreed that STEAM activities contributed to developing knowledge and skills in multiple disciplines. More specifically, a total of 93.5% of the teachers agreed or strongly agreed that STEAM activities enable interdisciplinary learning. Also, almost all the teachers (22.6% and 74.2% respectively) agreed and strongly agreed that the STEAM activities encouraged them to use their knowledge and skills in STEAM fields. Similarly, 93.5% of the teachers agreed or strongly agreed that designing STEAM projects and being an active participant helped them develop their knowledge and skills in STEAM subjects.

Arts subject

Regarding the arts, three of the teachers in the first camp and two of the second camp teachers expressed that STEAM activities developed art skills. The same result was reflected in six teachers' responses to the group-open-ended questions in the second camp. All teachers were convinced that STEAM activities would nurture and encourage students' knowledge and crafting skills in the arts.

> *[FC_INT-1]: I think everything was perfect, but some parts were missing. For example, in the science course, we are always technically oriented, but we had to think about the artistic aspect of design in the camp. Since we approached everything technically, we never thought about it artistically. When designing something new, we usually create it, but here in STEAM activities, we also pay attention to the design's aesthetic.*

[FC_INT-1]: Bence herşey çok güzeldi ama şöyle eksik kalan kısımlar da var. Yani mesela biz hep fen bilgisi derslerinde işi teknik olarak görürüz, ama burada sanatsal boyutunu da düşünmek zorunda kaldık. Biz her şeye teknik açıdan yaklaştığımız için hiç sanatsal yönden düşünmedik. Normalde yeni bir şeyler tasarlarken sadece tasarlarız, ama burada işin görselliğine de dikkat etmiş olduk.

[FC_INT-2]: The activities increase art and crafting skills. It also develops color and visual skills and processes of the production stage.

[FC_INT-2]: Etkinlikler sanat ve el becerisini arttırıyor. Ayrıca renk ve görsel becerileri ve üretim aşaması süreçlerini geliştiriyor.

STEAM activities involved using art and craft skills to a great extent in every project design step. Since art skills are inherently essential and pervasive in STEAM activities, teachers or students with such capabilities are inclined to develop artistic design ideas and better crafting of the project. What was aimed to achieve by STEAM activities in the camps was to help teachers or students exploit and realize their potentials in art skills and, as a result, become artistically inclined designers. In this respect, STEAM activities are great opportunities because they could use and exploit them to develop their arts competencies. We provided teachers with various types of e-textile technologies and different materials and tools of different sizes and colors in both camps. We allowed them to use as many art materials and tools as to craft design with artistic values. Science teachers stated that STEAM activities are capable of emerging and developing art skills. Some of the skills they mentioned included color and visual perception, color harmony, and 3D thinking. Moreover, they thought that such activities are bound to increase female students' interests and participation in STEAM fields. Since female students are better at hand-making works, they might be interested in STEAM activities more than male students.

[FC_INT-3]: Yeah, the skills that I was devoid of started to emerge gradually, and me, who had never handled a needle since my military service, can now sew. In other words, it shows how to tie a thread to a needle, which color fits which color, which things can be used more vividly, or to transform the design into three dimensions. I see that we can think in three dimensions, but I think

it's blunted because of not using it. To harness these skills, it is imperative to use them. Here in STEAM activities, when art is incorporated, I see that our skills are improving.

[FC_INT-3]: Evet, hiç olmayan becerilerin yavaş yavaş ortaya çıkabildiğini, askerlikten beri elime iğne iplik almamış ben, dikiş dikebiliyorum artık. Yani bir iğneye ipin nasıl bağlanabileceğini, hangi renge hangi rengin uyduğunu, daha canlı hangi şeyler kullanılabileceğini ya da tasarımı üç boyuta dönüştürmeyi gösteriyor. Bizim üç boyutlu düşünme yeteneğimizin olduğunu görüyorum, ama kullanmadığımız için köreldiğini düşünüyorum. Bunların ortaya çıkabilmesi için kullanılması çok önemli. Burada sanatı da dahil edince, bu becerimiz gelişiyor geliştiğini görüyorum.

[SC_INT-2]: Because of fashion, it becomes easier to draw girls to the STEAM area. In our school, the girls' participation in the maker workshops is very low, and there are 1-2 girls among all the students. So, I think these kinds of activities are more suitable for girls. Of course, it is suitable for everyone, but I think it would be more successful in attracting girls to the field.

[SC_INT-2]: Moda olunca kızları STEAM alanına çekmek daha kolay oluyor. Çünkü bizim okulumuzda maker atölyelerine kızların katılımı çok az, onca çocuğun içerisinde 1-2 kız var. O nedenle bu tür çalışmaların kızlar için daha uygun olduğunu düşünüyorum. Tabiki herkes için uygun ama kızları alana çekmek için daha başarılı olacağını düşünüyorum.

Science subject

Four of the first camp teachers and three of the second camp teachers stated in the interviews that STEAM activities have enormous potential to enhance science skills and concepts. Besides, all fourteen teachers who responded to the group open-ended questions in the first and second camps stated that STEAM activities encouraged to use and promote many science skills and knowledge about science concepts. According to those teachers, these activities could also teach various sorts of science concepts, including the basic electricity concepts and electric circuits. Similar findings were reflected in the survey data, where all the teachers responded that they learned a lot about the science concepts. As shown in Table 4.1, 90.3% of the teachers agreed or strongly agreed that they improved and updated their learning and understanding of circuits and electricity in the camp.

[FC_GR_OE-1]: In the field of science, they can be used to introduce circuit elements, the lamp brightness, the mechanism of turning LED on and off.

[FC_GR_OE-1]: Fen anlanında lamba parlaklığı, ışığın yanıp sönme mekanizması ile devre elemanları tanıtımında kullanılabilir.

[SC_INT-2]: Using STEAM activities, we can teach science concepts like electricity, electric circuit, sensor, and resistance. For example, in this short-circuit thing, we learned it by observing the facilitator while checking for short-circuiting. Okay, theoretically, we can see a short circuit when we look at how taps are stitched, but here in these activities, we understand it better when we sew it.

[SC_INT-2]: [Bu etkinlikleri kullanarak] elektrik, elektrik devresi, sensor ve direnç gibi kavramları verebiliriz. Örneğin bu kısa devre olayında, siz kısa devre için devreleri kontrol ederken bizde o sırada öğrendik. Tamam, teorik olarak kısa devre olup olmadığını bağlama şeklinden görebiliyoruz ama burada onu diktiğimizde daha iyi anlayabildik.

Engineering subject

Engineering design principles (also called design thinking phases) were embedded in STEAM activities. In both camps, groups of teachers were expected to design their STEAM projects following the specified design thinking stages. All ten of the first and second camps' teachers expressed that STEAM activities helped them develop engineering skills, particularly design thinking skills. The same result was reflected in teachers' responses to the survey and the group-open-ended questions. Thus, five of the first camp teachers and four of the second camp teachers remarked in the group-open-ended questions that hands-on activities encouraged them using the engineering design process, which helped them build design thinking skills.

Similarly, the survey result showed that a total of 90.3% of the teachers agreed or strongly agreed that they learned how to design a product following the design-oriented thinking steps (see Table 4.2). Yet, even though teachers were informed and encouraged to craft their project designs based on the stages described in the design thinking form, it was observed that they tended to skip the steps and use their own eclectic and improvised design methods instead. Unfortunately, during the camps, the groups who omitted design thinking stages when their project design was in its infancy had subsequently encountered some irreversible design problems. Adhering to the specified design thinking stages built mainly on engineering design processes may not be the only path to follow. Still, it is proven to be an effective and systematic means of organizing the design process.

> *[FC_INT-2]: The activities certainly spotlight the engineering design process and design-oriented thinking. I think that STEAM activities are practices that will fully develop engineering skills.*
>
> *[FC_INT-2]: Etkinlikler Kesinlikle [mühendislik tasarım sürecini ve tasarım odaklı düşünmeyi] ön plana çıkartıyor. Bence tam olarak mühendislik becerilerini geliştirecek etkinlikler.*
>
> *[SC_INT-3]: If these activities revolve around engineering design and design-oriented thinking skills, the emerged products will not only be made in a shorter time but also be more different and more original. But if it is said, "let's design this," without narrowing down the scope and giving any rules, the activities will take a very long time, and the product came out would be nonfunctional*
>
> *[SC_INT-3]: Zaten eğer bu etkinlikler [mühendislik tasarım ve tasarım odaklı düşün] becerisinin etrafında dönerse ortaya çıkacak ürünler hem daha kısa sürede hem daha farklı hem de daha özgün olacaktır. Ama bu eğer kapsam daraltılmadan, hiçbir kural verilmeden "hadi bunu tasarla" denilirse hem çok uzun süre gidecektir hem de ortaya çıkan ürünün işlevsel olmayacağını düşünüyorum.*

Mathematics subject

The weight of the discipline-based skills usage in a STEAM activity may depend mainly on how much those specific skills are being used during the activity period. The analysis of teachers' responses to qualitative data provided evidence that in addition to art, science, and engineering, groups of teachers also used skills and knowledge in other subjects such as mathematics and technology. Two of the teachers in the first camp and one of the second camp teachers stated in the group-open-ended questions that the STEAM activities promoted the acquisition of skills and knowledge in mathematics.

[SC_GR_OE-3]: Basic mathematical operations and exercises performed during the measurement can be said as mathematical skills.

[SC_GR_OE-3]: Temel matematik işlemleri ve ölçüm sırasında yapılan işlemler matematik becerisi olarak söylenebilir.

Technology subject

Additionally, three of the first camp teachers and all seven of the second camp teachers indicated in the group-open-ended questions that STEAM activities could enhance the acquisition of skills and knowledge in technology.

[FC_GR_OE-2]: The activities will improve coding and algorithmic thinking. I also think that learners will develop design, engineering, art, mathematics, and fine muscle skills.

[FC_GR_OE-2]: [Etkinlikler] kodlama ve algoritmik düşünmeyi geliştirecektir. Ayrica öğrenenlerde tasarım, muhendislik, sanat, matematik ve ince kas becerilerini geliştireceğini düşünüyorum.

Psychomotor skills

In both camps, while making their electronic textile projects, science teachers had performed many hands-on tasks from cutting and stitching to sewing, soldering, gluing, and folding. To carry out those tasks, they utilized several hand-operated tools like a needle, scissors, craft knife, etc. To put it another way, in addition to the brain, teachers benefitted from some parts of their body, especially hands and fingers, to design their projects. Data analysis from the interviews and open-ended questions provided evidence that STEAM activities could help learners develop fine or gross motor skills. All ten of the teachers in both the first and second camps expressed in the interviews that STEAM activities developed hand-making and finger-muscle skills. The same result was reflected in the qualitative answers to open-ended questions by five teachers in the first camp and all seven teachers in the second camp. Related to the students, teachers thought that students at first would have difficulties using their hands and fingers, but as they practice hands-on tasks, they would manage and get used to it. By its nature, STEAM activities entail using and coordinating small body muscles, leading to fine motor skills developments.

[FC_INT-5]: Students at first could struggle with sewing just like we did at the beginning of the camp. I am not the type of person who sews, but sewing became comfortable for me after pricking my hand with the sewing needle a few times. If we have reached this stage at the end of the 4th day, students will also improve hand and crafting skills if they collaboratively implement STEAM activities in the technology design course. Small muscle development is significant for students. We are no longer at the information level, so we need to use the skill. Students need to have talent, which is essential.

[FC_INT-5]: Öğrenciler el becerileri yüzünden ilk etapta zorlanabilir ki biz de zorlandık. Ben dikiş diken birisi değilim. Fakat, birkaç kere iğneyi elime batırdıktan sonra rahat oldu. 4. günün sonunda bu aşamaya geldiysek, öğrencilerin de teknoloji tasarım dersinde iş birliği yaparak STEAM etkinlikleri yaparlarsa el becerileri gelişecektir. Küçük kas gelişimi çok önemli çocuklar için. Biz artık bilgi basamağından değil, beceriyi kullanmamız gerekiyor. Çocukların beceri sahibi olması gerekiyor. Bu çok önemli.

[FC_INT-2]: The activities can also be used in daily life. As you know, ready-made kits that can teach electricity are sold even in stationery. The students take these kits, tie them up there, and it is over. This should not be the case. However, these STEAM activities are excellent tools to improve students' fine muscle skills.

[FC_INT-2]: Gayet günlük hayatta da kullanabilir. Bildiğiniz üzere, elektrik konusu ile ilgili kırtasiyelerde dahi hazır setler satılıyor. Çocuklar bu setleri alıp onu oraya bağlıyor ve bitti. Olay bu değil. Fakat, burada yapılanlar çocuğun kas becerisini geliştirebilecek güzel etkinlikler.

[SC_GR_OE-5]: We believe that these activities will improve students' fine muscle skills.

[SC_GR_OE-5]: Öğrencilerin ince kas becerilerini geliştireceğini düşünüyoruz.

In addition to the qualitative data results described above, the contribution of STEAM activities to fine muscle skills improvement was also evidenced in the quantitative data. The survey result showed that 93.6% of teachers agreed or strongly agreed that STEAM activities would help students improve fine muscle and handcrafting skills (see Table 4.1).

4.2.3 Design principles for the implementation of the STEAM activities in school

In school settings, STEAM activities could be adapted to a wide variety of areas in different subjects. In particular, these hands-on science and art projects are likely to be used not only for learning science topics but also for learning various subject matters in multiple disciplines ranging from science and technology to chemistry, biology, programming, and astronomy.

In a STEAM camp, managing the number of participants (students or teachers) is essential to tackle the challenges occurring during its implementation. Organizing a STEAM camp with an unmanageable number of students is doom to failure. Therefore, teachers should invite as many students as they can handle. It seems that a teacher can deal with not more than twenty students in a STEAM camp. It is highly suggested for the teachers not to go over this number and try to control even more students unless they are accompanied by one or more than one facilitator like other teachers who are ready to provide additional support and help during the camp. Furthermore, in a crowded classroom with more than twenty students, it would be better and very useful to divide students into two, three, or even more feasible and manageable groups that a teacher could handle by herself/himself. A teacher can increase the number of students in the camp, depending on the number of facilitators available to provide instructional scaffolding to the groups in their project design process.

Organizing and implementing a STEAM camp are two interconnected cooperative processes that require the involvement of teachers, parents, and school administrators. It is suggested that not only teachers but also school administrators and parents should involve in organizing and implementing a STEAM camp. A teacher by himself or herself is unlikely to be successful in doing a camp from scratch without receiving any help from others, specifically school administrators and then parents. Hence, there must be cooperation and collaboration between a teacher and school administrators, which is supported by parents.

The STEAM activities are proven to be suitable practices to help middle school students get the fundamental knowledge and understanding of electricity and circuits. However, for students to fully leverage its benefits, the level of complexity and difficulty of the STEAM activities must be tailored to the students' current levels of knowledge and skills related specifically to e-textile technologies and circuitry. Because students, especially in 5th and 6th grades, might struggle with doing a few of the STEAM activities.

4.3 Experiences and opinions about the implementation of STEAM activities

This section covers teachers' experiences and opinions on the implementation of STEAM activities in different educational settings. There are two parts in this section. The first part includes the findings related to the implementation of the activities in the classroom, while the second part focuses on the findings related to the implementation of the activities in a training camp.

4.3.1 Implementation of activities in the classroom

4.3.1.1 Applicable areas

The use of STEAM activities may be more appropriate for some subjects than others. The result revealed that STEAM activities could be used to teach concepts of many fields, from science and technology to chemistry, biology, programming, and astronomy. Among these subjects, ten teachers' responses to open-ended questions from the first camp pointed to the concepts that belong to science and technology.

> *[FC_POST_OE-8]: The light sensor's ability to emit light in different colors could allow students to visually test the subject and learn more permanently in science subjects.*

[FC_POST_OE-8]: Işık sensörünün farkli renklere uygun ışık yayması fen konularında konunun görsel yönden öğrencinin test etmesini ve daha kalici öğrenmesini sağlar.

One teacher in the interviews and six teachers in open-ended questions from the first camp, and three teachers in open-ended questions from the second camp stated that STEAM activities could be adopted to teach some chemistry concepts.

[FC_INT-1]: For example, in the topic of atoms, LEDs can be applied to show students either protons and neurons or nucleus and orbits.

[FC_INT-1]: Örneğin; atom konusunda, çocuklara proton nötron veya çekirdek ile yörüngeleri göstermek için ledler uygulanabilir.

Besides, in open-ended questions, six teachers from the first and second camps mentioned that it is possible to teach biology concepts through these maker-centered activities. According to those teachers, STEAM activities could be adopted to help students learn various biology concepts, including photosynthesis, DNA, body systems, force, motions, etc.

[SC_POST_OE-5]: These STEAM activities can be easily used in many fields such as science and technology, DNA and genetic coding, mitosis and meiosis division, force and motion, matter, etc.

[SC_POST_OE-5]: Fen ve teknoloji ile ilgili birçok konuda kullanılabilir. DNA ve genetik kod, mitoz ve mayoz bölünme, kuvvet ve hareket, madde. vs de rahatlıkla kullanılabilir.

Arduino programming language appears to be other subject teachers though STEAM activities could help to teach. Learning Arduino programming language was also one of the most common reasons teachers opted to come to the camp. The analysis of the responses to open-ended questions by one teacher from the first camp and three teachers from the second camp revealed that STEAM activities could be an effective means of teaching students the Arduino programming language.

[SC_GR_OE-7]: The STEAM activities can be used for parallel circuits, but they would be more suitable for the coding lesson.

[SC_GR_OE-7]: Paralel devreler için kullanilabilir ancak kodlama dersi için daha uygun olur.

Teachers highlighted some basic Astronomy concepts in their answers to the questions that could be taught through STEAM activities. Two teachers from the first camp and a teacher from the second camp expressed in their responses to open-ended questions that it is possible to modify STEAM activities to teach several Astronomy concepts, including the earth-sun-moon system, space, universe, etc.

> *[FC_GR_OE-4]: For the current 5th class program, these activities can be used for the solar sun unit after changing the unit's content a little bit, and also earth, sun, and moon models can be made.*
>
> *[FC_GR_OE-4]: Mevcut 5. sinif programı içerisinideki dünya güneş ay ünitesinin içerisi bir miktar değistirilerek kullanılabilir. Dünya, günes ve ay modelleri yapılabilir.*

The teaching of basic health concepts is the last field teachers thought STEAM activities could be used. Two teachers' responses to open-ended questions from the first camp showed that the STEAM activities could be adapted to the middle school units, including the health topics.

> *[FC_POST_OE-1]: These activities can also be used in health units.*
>
> *[FC_POST_OE-1]: Bu etkinlikler sağlık konularının yer aldığı ünitelerde de kullanılabilir.*

4.3.1.2 A manageable number of students

This section covers teachers' remarks regarding the number of students they can manage to handle during the implementation of STEAM activities. Since schools are differentiated from one another in terms of offering physical conditions and opportunities, it's bound to be differences in the number of students they have in each classroom. A teacher from the first camp and three teachers from the second camp expressed in the interviews that the number of students they can handle shouldn't exceed twenty students. They thought that it would not be possible to control a classroom larger than twenty students.

[FC_INT-2]: I can do [these activities] in the science applications course. Our classes consist of 32 students. I can do the first [activities] in the regular class and manage the students, but afterward [for the other remaining activities], it wouldn't be easy to control 32 students. For example, there are 17-18 students in the science applications course. I can handle and do all the activities in this course.

[FC_INT-2]: Bunu bilim uygulamalarında yapabilirim. Bizim sınıflarımız 32 kişilik. Normal sınıfta ilkini yapabilirim, sınıfı kontrol ederim ama sonrasında 32 kişiyi kontrol etmek kolay olmaz. Ama mesela bilim uygulamaları dersinde 17-18 kişi oluyor. Orada halledilir. Onlarla yapılabilir.

However, managing students during the implementation of STEAM activities may not be as easy as teachers expressed in the interviews. The reason is that students in middle school, as stated by the following teacher from the second camp, are hyperactive and not used to obey the classroom discipline, and also have their attention quickly disrupted. Based on teachers' responses, it could be said that individual teachers without any support from the other teachers or someone outside is bound to face many difficulties during the implementation of STEAM activities.

[SC_INT-3]: A group of 20 students can be managed but when it is over 20, controlling and managing them becomes very difficult. For example, I have 29-30 students in my school, and when we do activities in the laboratory, we face difficulties. The group you are addressing is a very active group between the ages of 8-14, so their attention could be easily distracted. Since they tend to react to the stimuli around them, so it is hard to control them. The maximum number is 20 students, but the ideal number is between 10 and 20 students.

[SC_INT-3]: 20 kişilik bir grup yönetilebilir ama 20 kişinin üzerine çıkıldığı zaman bunun kontrol edilmesi çok zor oluyor. Örneğin benim kendi okulumda 29-30 kişilik sınıflarım var, laboratuvarda etkinlik yapacağımız zaman 30 kişinin zorluğunu çekiyoruz. Hitap ettiğiniz grup 8-14 yaş arası çok hareketli bir grup. İlgisi çabuk dağılıyor. Etrafındaki uyaranlara hemen tepki veriyorlar o yüzden onu kontrol etmek zor. En fazla maksimum 20. 10-20 arası ideal.

It seemed that one of the most foreseeable hurdles for teachers planning to implement STEAM activities in their classrooms would be how to manage many groups of students while they are working on their project design. Considering that the public schools have crowded classrooms with at least more than thirty students on average, it would be almost impossible for teachers to establish management and control during the activities, teachers said. In such cases where there are many students in each class, the students can be divided into manageable groups, and each group can separately implement STEAM activities at different times.

4.3.1.3 Role of the stakeholders

Several factors could interfere in making STEAM activities in or out of school. The findings showed that school principals could also play a significant role in the activity implementation in addition to science teachers. A teacher interviewed in the first camp explained that the successful implementation of STEAM activities rested firstly on teachers' shoulders. Accordingly, teachers would be in the first place to scaffold students' STEAM design, show them how to make activities, and solve their problems.

> *[FC_INT-4]: Of course, I would show students [the activities] thoroughly because it is not working well when leaving everything to the student. The student does not understand anything. During the exercises, I have to walk around as a facilitator. The student will continuously consult me, and I will give him feedback. I have a lot of work to do here. You cannot put the activity paper in front of the student and leave it to him altogether.*
>
> *[FC_INT-4]: Tabii ki ben de [etkinlikleri] anlatacağım; tamamen öğrenciye bırakınca olmuyor. Öğrenci bir şey anlamıyor. Benim burada sürekli danışman olarak dolaşmam lazım, öğrenci sürekli bana danışacak sürekli bilgi alacak ben de ona sürekli dönüt vereceğim. Burada bana inanılmaz fazla iş düşüyor. Öğrencinin önüne [etkinlik] kağıdini verip tamamen ona bırakmak olmaz.*

All the responsibilities and works that are required to implement STEAM activities in the school could be a significant burden that teachers by themselves might not be expected to bear. A teacher interviewed in the first camp expressed that school principals can facilitate STEAM activities' enactment with their long-lasting efforts, profitable decisions, and continuous support. As a result, preparing suitable conditions for interdisciplinary activities requires sharing and distributing activity-related responsibilities among stakeholders. Otherwise, imposing all the activity works and efforts on science teachers may bring a poor outcome in applying STEAM activities.

> *[FC_INT-5]: School principals' view of these activities is very important. It is also imperative that the school principal supports the teacher because school principals have only one criterion: the test results. The school's success in the tests or the high school entrance exam is measured in the same way as the teacher's success. Therefore, family and school administration may react unfavorably to the implementation of activities in 8th grade, but I think it will be more comfortable to apply these activities in lower classes.*

> *[FC_INT-5]: Okul müdürlerinin bu noktada bu tür etkinliklere bakışı ve öğretmeni desteklemeleri çok önemli. Çünkü okul müdürlerinin tek değerlendirme kriteri var, o da test. Okulun test durumundaki ya da şimdi liselere giriş sınavındaki başarısı öğretmenin başarısı da aynı şekilde ölçülüyor. O nedenle, [bu etkinliklerin] belki 8. sınıflarda uygulanmasında aile ve okul yönetiminin tepkisi olabilir ama alt sınıflarda daha rahat uygulanacağını düşünüyorum.*

4.3.1.3.1 Suitability and applicability of STEAM activities for teaching electricity and circuits

Science teachers were asked to indicate their opinions and thoughts about whether the STEAM activities they had engaged in were suitable for teaching electricity and circuits. Six teachers from the first camp and three teachers from the second expressed in the interviews that STEAM activities could teach students electricity and circuitry concepts. According to the teachers, STEAM activities could better support students' learning of electrical circuitry concepts than the traditional practices currently applied in the school. Furthermore, the survey result showed that about 94% of teachers agreed or strongly agreed that STEAM activities could be used to teach electricity and circuitry (see Table 4.1).

[FC_INT-5]: These activities are beneficial and practical. It will be convenient for the students as well, mainly because it gives a lot of freedom. Sewing yarn provides incredible flexibility for students to make their designs. The felt is also very easy to use. Because in the past, in science classes, we used to use a battery, a battery bed, conductive wires, and a light bulb, but the tools we used before are now outdated. Therefore, these new things will attract student's attention more. Thanks to these new technologies, the students will be able to adapt to our time's technology. We still have battery beds in our labs, but you do not get much efficiency if you use them. There is also resistance. Due to the resistance, for example, one of the bulbs you connect in parallel becomes too light, or when you connect in series, the end bulb becomes less lit. Therefore, the losses due to data resistance are much less in this new method.

[FC_INT-5]: [Bu etkinlikler] çok kullanışlı ve pratik. Yani öğrenci için de çok pratik olacaktır. Özellikle çok özgürlük veriyor. Orada dikerek o iplik inanılmaz bir esneklik sağlıyor çocuklar için tasarımlarını yapmaları için. Keçenin kullanılması yine aynı şeklide çok büyük kolaylık çünkü biz eskiden fen derslerinde, bir pil, bir pil yatağı, iletken teller ve ampul kullaniyorduk. Ama artık günümüz teknolojisinde bunlar geride kaldı. Dolayısıyla, bu yeni şeyler çocuğun ilgisini çok daha fazla çekecektir. Hem de bu yeni teknolojiler sayesinde çağımızın teknolojisine adapte olacaktır. Artık hala bizim laboratuvarlarımızda pil yataklarımız var ama bunları kullandığınızda çok verim alamıyorsunuz. Ayrıca direnç de söz konusu. Dirençten dolayı örneğin paralel bağladığınız ampulün birisi fazla yanıyor ya da seri bağladığınızda sondaki ampul daha az yanıyor. Dolayısıyla veri dirençten kaynaklanan kayıplar bunda çok daha az.

Besides, as teachers described, STEAM activities could introduce students to many basic electricity and circuitry concepts ranging from circuit components to electrical symbols, the brightness of the bulb, resistance, and series and parallel circuits.

[FC_INT-6]: These activities could be used for students. Students can learn circuit elements and symbols. They can also learn if the bulb brightness is evenly lit. Besides, they can learn resistors and how bulbs are connected. Additionally, they can learn serial-parallel connectıon. So, it is appropriate.

[FC_INT-6]: [Öğrenciler için bu etkinlikler] kullanılabilir. [Öğrenciler] devre elemanlarını ve sembollerini öğrenebilir. Ampul parlaklığının eşit yanıp yanmadığını öğrenebilir.

Dirençleri, ampullerin bağlanma şekillerini öğrenebilir. Seri-paralel bağlamayı öğrenebilir. Uygun.

[SC_INT-2]: Yes, I think that if the teacher plans the activities correctly, it can be applied to students. All learning objectives, including OHM law and the installation of simple electrical circuits, can be obtained.

[SC_INT-2]: Evet, öğretmen düzgün bir şekilde planlarsa çocuklara uygulanabileceğini ve bu OHM kanununu, basit elektrik devrelerinin kurulumu gibi bütün kazanımların verilebileceğini düşünüyorum.

Like the teachers interviewed, the first camp twelve teachers and the second camp eight teachers showed in their responses to open-ended questions that STEAM activities are appropriate to transmit understanding and knowledge of electricity and circuits to students. They also stated that most of the objectives in the science curriculum might be achieved through STEAM activities.

[FC_GR_OE-4]: I think it is appropriate to teach science concepts such as short circuit and grounding. Also, I could teach students to pay attention to the polarity of the electric circuits.

[FC_GR_OE-4]: Kısa devre, topraklama kavramını öğretmek için uygun olduğunu düşünüyorum. [Öğrencilere] elektrik devresi kurarken devre kutuplarına dikkat etmesi gerektiğini öğretirim.

[FC_GR_OE-3]: I think that serial and parallel circuits can be taught funnily. These activities meet the objectives appropriate to the level of middle school students.

[FC_GR_OE-3]: Seri ve paralel devrelerin eğlenceli bir şekilde öğretilebileceğini düşünüyorum. [Bu etkinlikler] ortaokul öğrencilerin seviyelerine uygun kazanımları karşılıyor.

[SC_GR_OE-6]: These activities can be used for demonstration at science fairs. They can be mostly applied in electrical subjects to increase students' interest in the course.

[SC_GR_OE-6]: [Etkinlikler] bilim fuarlarında gösteri amaçlı kullanılabilir. Öğrencilerin derse ilgisini artırmak için özellikle elektrik konularında olabilir.

4.3.1.3.2 Use and appropriateness of STEAM activities for middle school students

Science teachers were asked in interviews and open-ended questions about how STEAM activities suit the middle school level. Six of the teachers at the first camp and three of the teachers at the second camp expressed in the interviews that, irrespective of the students' grade levels, STEAM activities are appropriate and can be used for middle school students. Also, the analysis of the responses to the group open-ended questions by seven teachers from the first camp and five teachers from the second camp resulted in the same view.

> *[FC_INT-2]: The content of the activities is pleasant and suitable for middle school.*
>
> *[FC_INT-2]: Etkinliklerin içeriği ortaokul için uygun ve güzel*
>
> *[SC_GR_OE-3]: The content and design of these activities can be applied in circuit teaching. [Through these activities], we can successfully teach how to establish a parallel circuit. I think these are successful learning activities.*
>
> *[SC_GR_OE-3]: [Bu etkinlikler] devre öğretiminde içerik ve tasarim olarak uygulanabilir. [Bu etkinlikler sayesinde] paralel devrenin nasıl kurulduğunu gayet başarılı bir şekilde öğretebiliriz. Başarılı etkinlikler olduğunu düşünüyorum.*
>
> *[FC_INT-2]: Activities are suitable for the middle school level. Series-connected circuits are already very intriguing to students. Now students are bored with conducting a series of circuits with conductive wires and bulbs anymore. I think they would be more interested in these activities. It will be more beautiful, even more so. They will do something different than the activities they do in primary school. In primary school, we already use light bulbs and switches in the series-connected circuits. If I look from this perspective, I can do these kinds of activities next year.*
>
> *[FC_INT-2]: [Etkinlikler ortaokul seviyesi için] uygun. Zaten seri bağlı devreler çocukların çok ilgisini çekiyor. Artık öğrenciler iletken tel ve ampul ile seri bağlı devre yapmaktan da sıkıldı. Bence bunlar daha çok ilgilerini çekecek. Daha güzel olacak, hatta daha çok hoşlarına gidecek. İlkokulda yaptıkları etkinliklerden daha farklı bir şey yapmış olacaklar. Çünkü ilkokulda da seri bağlı devrede sadece ampul ve anahtar kullanıyoruz, öğrenci zaten*

bunu yapıp gelmiş oluyor. Bu açıdan bakacak olursam seneye bu tür çalışmalar yapabilirim aslında.

In Turkey, middle school education is compulsory and composed of four grade levels: 5, 6, 7, and 8. Even if most of the teachers advocated that the middle school students could benefit from the STEAM activities, some of the teachers were concerned that all seven of the STEAM activities might not be appropriate for all grade levels. For instance, five teachers stated that few STEAM activities are beyond 5th and 6th-grade students' capabilities, especially the last STEAM activity. The reason is that the final activity required participants to design a color-changing scarf with a Lilypad Arduino USB, a Flora color sensor, seven Lilypad pixel board, and a conductive thread. Teachers thought that activities involving higher hand-making and crafting skills are more suitable for 7th and 8th-grade students because students of fifth and sixth grades are young and lack fundamental crafting skills, mainly sewing.

[SC_GR_OE-5]: The activities are suitable for the middle level and could be applied for the 7th and 8th grades.

[SC_GR_OE-5]: Etkinlikler ortaöğretim düzeyi için uygun ve 7. ve 8. sınıf için kullanılabilir.

[FC_GR_OE-1]: These activities can be used to demonstrate electrical circuit elements for 7th and 8th-grade students.

[FC_GR_OE-1]: [Bu etkinlikler] ortaöğretim 7 ve 8'lere elektrik devre elemanlarını göstermek için uygulanabilir.

[SC_INT-1]: I have also written in the activity booklet you gave me. I think it is more suitable for the 7th and 8th grades and I think it will be much more successful. The 7th and 8th-grade students, especially female students interested in fashion, would be very interested in these activities, and you can get a lot of feedback from them. I want to think about this in the 5th and 6th grades as well, but in the country, our students are growing far from them. Besides, fine muscle skills are also very important for these activities, but unfortunately, these skills are not developed in the 5th and 6th-grade students.

[SC_INT-1]: Bana verdiğiniz etkinlik kitapçığına da yazdım ben 7. ve 8. sınıflar için daha çok uygun olduğunu düşünüyorum ve çok daha başarılı olacağını düşünüyorum. 7. ve 8. sınıflarda özellikle

modayla ilgilenen kız öğrencileri [bu etkinliklerle] çok fazla ilgili olur ve onlardan çok fazla bir geri dönüt alabilirsiniz. Bunu 5. ve 6. sınıflarda da düşünmek istiyorum aslında ama ülkede çocuklarımız bunlardan gerçekten çok uzak büyüyorlar. Ayrıca [bu etkinlikler için] ince kas becerileri çok önemli fakat 5. ve 6. sınıflardaki öğrencilerde bu beceriler çok gelişmiyor maalesef.

[SC_INT-2]: The last few activities can be a little detailed for 5th grade, or if simplified a bit, simple circuits can easily be applied in the classroom. However, they fit for 7th and 8th-grade students. Since the exam may be stressful for the 8th grade, you can get different feedback from the students in that grade.

[SC_INT-2]: Sondaki etkinlikler 5. sınıflar için biraz ayrıntılı olabilir, biraz basitleştirilerek basit devreler yapılabilir. Ama 7. ve 8. sınıflarda uygun. 8'lerde de sınav stresi olabileceği için farklı dönütler alabilirsiniz çocuklardan.

The survey results also showed that many teachers thought students would not struggle much with making STEAM project designs (see Table x). To illustrate, 61.3 of the teachers agreed or strongly agreed that students would not have difficulty creating and designing their STEAM project designs. On the contrary, a small number of teachers (9.7%) disagreed or strongly disagreed that it would be challenging for students to do the activities.

4.3.2 Implementation of the activities in the camp

This part describes the science teachers' experiences and opinions about the implementation of STEAM activities in the first and second camps. The findings related to this part are split into five categories: adequacy of materials and tools, arts in STEAM activities, interactions and collaborations in STEAM activities, the characteristics attributed to TEAM activities, and the content components of the STEAM Activities.

4.3.2.1.1 Adequacy of materials and tools

The adequacy of materials and tools refers to the teachers' views on the quantity and diversity of e-textile materials and crafting tools available in the first and the second camp. The researcher's observations from the pilot studies revealed that some materials, particularly those used for design and crafting purposes, were missing and inadequate to enable them to craft their designs the way they wanted. Based on the lessons learned from the pilot studies, the camp environment was equipped with as many materials as possible so that material scarcity couldn't hinder groups of teachers from crafting their STEAM projects. The qualitative and quantitative findings and the observations from both camps showed that teachers were content with the materials' quantity and diversity and crafting tools available in the camp. Since there were many sorts of materials to choose from, it was observed that teachers sometimes couldn't decide which materials they should go on. The analysis of all ten teachers' interview transcripts in both camps and two teachers' responses to the group open-ended questions showed a sufficient number of materials and tools in the camps. Furthermore, the teachers who were satisfied with the camp materials also made some suggestions/remarks about the materials and the material-related problems described in the suggestions and problems section.

> *[SC_GR_OE-7]: There were both various and abundant amounts of the materials.*
>
> *[SC_GR_OE-7]: Malzemeler hem çok çeşitliydi hemde çok miktarda vardı.*
>
> *[SC_GR_OE-2]: The materials were also quite sufficient.*
>
> *[SC_GR_OE-2]: Malzemeler de gayet yeterliydi.*

The survey results also indicated that the teachers were commonly happy with the materials' variety, quality, diversity, and functionality. As shown in Table 4.2, almost all teachers (93.5%) disagreed or strongly disagreed that the poor-quality materials were used in the camp for the activity design. Similarly, 29% and 48.4% of the teachers agreed and strongly agreed that the STEAM training camp was packed with a wide variety of materials, incredibly wearable e-textile technologies. Moreover, most teachers (29% and 64.5% respectively) disagreed and strongly disagreed that the camp materials and tools were useless, unpractical, and nonfunctional. In terms of the materials' diversity, %74.2 of the teachers agreed or strongly agreed that the artistic and design-related materials available in the camp had a good variety.

Table 4.2 Materials and tools

Items	*M*	*SD*	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
The camp had enough materials related to art and design to design activities.	5.84	1.24	-	3.23	3.23	3.23	22.58	32.26	35.48
I had difficulty finding the materials I needed for activity designs in the camp.	2.19	1.42	38.71	35.48	9.68	3.23	9.68	3.23	-
The camp had sufficient wearable e-textile materials.	5.65	1.45	-	-	12.90	12.90	9.68	25.81	38.71
The quality of the materials I used for activity designs in the camp was poor.	1.61	0.88	54.84	35.48	6.45	-	3.23	-	-
The camp had enough variety of art and design-related materials to design activities.	5.94	1.34	-	3.23	3.23	9.68	9.68	29.03	45.16
The materials given for activity designs at the camp were useless.	1.48	0.85	64.52	29.03	3.23	-	3.23	-	-
There was a sufficient variety of wearable e-textile materials in the camp.	6.06	1.21	-	-	6.45	6.45	9.68	29.03	48.39

4.3.2.1.2 Arts dimension in the STEAM activities

STEAM activities are designed to help learners explore hands-on learning at the intersection of design, art, and science. The art dimension, therefore, could be viewed as an indispensable part of designing a STEAM project. Science teachers gave a wide variety of positive expressions and views regarding how art played a crucial role in their STEAM designs. Five of the teachers in the first camp and all four of the second camp teachers expressed in the interviews that the design of current STEAM activities encouraged them to use and develop artistic skills. For instance, one of the first camp teachers explained that despite not knowing much about arts staff, you either develop your artistic skills or add new skills to your creative skills repertoire after being fully immersed in making a STEAM design.

> *[FC_INT-3]: Yes, the skills that I am devoid of started to emerge gradually, and I, who had never handled a needle since my military service, can now sew. In other words, it shows how to tie a thread to a needle, which color fits which color, which things can be used more vividly, or to transform the design into three dimensions. We can think in three dimensions, but I think it is blunted because of not using it. It is imperative to use them to emerge those skills. In STEAM activities, when art is incorporated, I see that our skills are improving.*

> *[FC_INT-3]: Evet, hiç olmayan becerilerin yavaş yavaş ortaya çıkabildiğini, askerlikten beri elime iğne iplik almamış ben, dikiş dikebiliyorum artık. Yani [bunlar] bir iğneye ipin nasıl bağlanabileceğini, hangi renge hangi rengin uyduğunu, daha canlı hangi şeyler kullanılabileceğini ya da tasarımı üç boyuta dönüştürmeyi gösteriyor. Bizim üç boyutlu düşünme yeteneğimizin olduğunu görüyorum ama kullanmadığımız için köreldiğini düşünüyorum. Bunların ortaya çıkabilmesi için kullanılması çok önemli. Burada sanatı da dahil edince, bu becerimiz gelişiyor; geliştiğini görüyorum.*

Besides, one teacher from the second camp mentioned that the design process you got through in art-focused activities helped them cultivate their art skills, steer their attention towards arts and fashion in project design, and think about how they bring together their design components. The contribution of STEAM activities to the development of artistic skills was also evidenced in quantitative data. The survey result showed that 80.6% of teachers agreed or strongly agreed that they think the camp helped them use and develop their artistic skills (see Table 4.1).

> *[SC_INT-1]: It enables using artistic skills and develops them. Actually, I have not followed any fashion-related things before, but now I will check out the color matching. I start thinking about the questions as to what I should place on this design, what wearable technology can be sewed on these clothes, what colors can be used, how the project design can be planned.*

> *[SC_INT-1]: Sanatsal becerileri kullanmayı sağlıyor ve geliştiriyor. Aslında ben modayla alakalı bazı şeyler takip etmemiştim daha önce ama şimdi gidip renk uyumlarına bakacağım. Şunları düşünmeye başlıyorum: mesela bu tasarım üzerine ne yerleştirmeliyim, bu kıyafetlerin üstüne dikibileceğim giyilebilir teknoloji neler olabilir, hangi renkler olabilir, nasıl planlanabilir?*

It can be seen from the data in Table 4.1 that more than half of the teachers (26% and 32.1%, respectively) agreed and strongly agreed that they were able to transfer the art dimension to their project designs sufficiently. Furthermore, during the making of the STEAM activities, it was observed that the groups of science teachers from the first and second camps used their artistic endeavors to produce a well-crafted design. A similar view was also reflected in the findings stemmed mainly from teachers' responses to the group-open-ended questions. Teachers noted that they used various strategies to establish an aesthetic and attractive design in their STEAM project. The analysis of the answers to the group-open-ended questions revealed that all fourteen of the teachers in both first and second camp tried to achieve the harmony of colors and color integrity in their STEAM project. Additionally, two of the second camp teachers expressed in the interviews that the first thing they tried to maintain during the design process was to ensure that the colors of materials they selected for the design worked well. It was also observed that after the second or third activity, groups started to became aware of the fact that when the materials selected for the design did not match in color after being joined by sewing, the final design would be doomed to be unattractive.

[FC_GR_OE-4]: We tried to match the bead color to the color of the felt.

[FC_GR_OE-4]: Boncuk rengi ile keçe rengi arasında uyum sağlamaya çalıştık.

[FC_GR_OE-1]: Since it is a lighthouse, we thought of a mix of red and white colors. We paid attention to the colors that attracted attention, and we felt that the red and green shades matched each other.

[FC_GR_OE-1]: Deniz feneri olduğu için kırmızı ve beyaz renk karışımı bir tasarım düşündük. Dikkat çeken renkler olmasına dikkat ettik, kırmızı ve yeşil renk tonlarının birbirine uyumlu olduğunu düşündük.

[SC_GR_OE-2]: We paid attention to felt fabric, beads, and color tones. We paid attention to using more colored felts for visuality and equal-sized fabrics.

[SC_GR_OE-2]: Keçeli kumaş, boncuk, renk tonlarına dikkat ettik. Görsellik için daha renkli keçeler kullanmaya ve boyut olarak eşit kumaşlar kullanmaya dikkat ettik.

In their answers to the group-open-ended questions, all thirteen of the first and second camp teachers stated that they tried to add visual richness and simplicity to the project design. For doing that, they strived to embellish the project design with a wide assortment of colored materials, including bead, ribbon, thread, felt, etc. More specifically, while establishing the visually rich project design, teachers also tried to keep their project design as simple as possible so that the excessive use of materials for the decoration could not distort or obscure the artistic parts of the project design. The following lighthouse project design sample shown in figure 4.1 is one of the project design teachers crafted elegantly and artistically. At first glance, the project outlook gives a sense of artistic authenticity and creativity. A group of teachers who designed the project used and mixed the right combination of colors, cut the felt straight, produced nicely curved shapes, and sew good whip stitches.

Figure 4.1. A lighthouse project design sample

> *[FC_GR_OE-2]: We used colored beads, ribbons, and hearted accessories. Integrity was appropriate but was visually challenged.*
>
> *[FC_GR_OE-2]: Renkli boncuklar kullandık, kurdele kullandık, kalpli aksesuar kullandık, bütünlük olarak uygun fakat görsel olarak zorlandık.*

[FC_GR_OE-5]: We used ribbons, colored yarns, black felt, and white and red colors, and we tried to be attentive that the design is good in terms of visual richness.

[FC_GR_OE-5]: Kurdele kullandık, renkli iplikler kullandık, siyah keçe kullandık, beyaz ve kırmızı renkleri kullandık. Tasarımın görsel zenginlik açısından fazla olmasına dikkat ettik.

[SC_GR_OE-1]: We used beads of different sizes and colors to establish visual integrity.

[SC_GR_OE-1]: Görsel bir bütünlük kazanması açısından farklı boyutlarda ve renklerde boncuklar kullandık.

Figure 4.2. Wristband project design sample

However, observations and project design samples revealed that some groups of teachers just arbitrarily attached or fastened different sort of crafting materials which didn't hang or sit quite right on the place they had positioned (see figure 4.1). On the other hand, some groups did pay attention to the delicate and fine sewing and tried to maintain the symmetry between design components. The same idea about using delicate and fine sewing techniques came from the teachers' responses to the group's open-ended questions. Two of the first camp teachers and all seven of the second camp teachers remarked that they tried to use different types of stitches so that their design visually looked good. Oversewing, tacking, and running stitches were three of the stitching types they applied to attach crafting materials, especially fabric, and connect wearable e-textile electronics. Furthermore, to get a design looking better in symmetrical matters, they mostly worked on two things: alignment and cutting.

[SC_GR_OE-3]: We used purple colored fabric, colorful flower patterns and paid attention to color matching, smooth stitches, and symmetry.

[SC_GR_OE-3]: Mor renkli kumaş, renkli çiçek modelleri, renk uyumu, dikişlerin düzgün olması ve simetriye dikkat ettik.

[SC_GR_OE-2]: We made shapes by using felts; we ensured that the colors matched. We used ratio and proportion to cut the felts. We also tried to make sure that the shapes have the same size.

[SC_GR_OE-2]: Keçeleri kullanarak şekiller yaptık, renklerin uyumlu olmasına dikkat ettik, keçeleri keserken oran orantıyı kullandık, şekillerin aynı boyutta olmasını sağlamaya çalıştık.

The other thing teachers mentioned was about female dominance over males in artistic skills. During the observations from the first and second camps, most of the groups kindly confessed that the female-dominated group's well-designed project was a clear indication of female dominance over males in aesthetics and textile design skills. Moreover, two of the teachers from both the first and second camps expressed in the interviews that females, compared to males who tend to focus on functionality rather than arts, naturally tend to be better than males in artistic and handicraft skills. Therefore, to add both functional and artistic aspects to the design, it would be wise to form a group with a mix of male and female students.

[FC_INT-5]: That also appeared when comparing ourselves with other groups. We are former students of traditional education. When we look at women's works in terms of handcraft and creativity, women give more attention to details. We did not pay much attention to the details; we said we could solve the problem, let it work, then let's visualize it a bit, but we felt a little behind when we looked at other groups. Then we got things together. We tried to pay more attention to the color harmony of our design.

[FC_INT-5]: Zaten o kendimizi diğer gruplarla karşılaştırırken de ortaya çıktı. Şimdi biz geleneksel eğitimin ürünleriyiz, bayanların yaptıkları çalışmalara baktığımız zaman hem el becerisi hem de yaratıcılık olarak, bayanlar detaylara daha çok önem veriyor. Biz detaylara çok önem vermedik, biz sorunu çözelim, işe yarasın tabi sonra biraz daha görselleştirelim dedik artık, diğer gruplara bakınca kendimizi biraz geride hissettik. Ondan sonra şeyi toparladık. Biraz daha çalışmalarımızın renk uyumuna dikkat etmeye çalıştık.

[SC_INT-2]: Students' design products are poor and devoid of any aesthetic value. Girls become uncomfortable because of that, but it is okay for boys. For example, the reason for a design to look good is probably the touch of a woman's hand at the design stage. Many things like art, reading, writing, and literature can be integrated into STEM. Art is a must. We walk on the road, but there is no aesthetics, not even on our sidewalks. Are not the engineers doing this? If the engineer does not have an artist's perspective, how will it be? We should give our students an understanding of aesthetics.

[SC_INT-2]: Estetik. Çocukların yaptığı ürünler yamuk, hiçbir estetik değeri yok. Kızlar rahatsız oluyor, ama erkekler için sorun değil. Mesela, bunun güzel görünmesinin sebebi muhtemelen tasarım aşamasında bir kadın elinin değmesidir. STEM içine sanat, okuma, yazma, literature gibi bence birçok şey entegre edilebilir. Sanat olmazsa olmaz. Yolda yürüyoruz hiçbir estetik yok, kaldırımlarımızda bile yok. Bunları mühendisler yapmıyor mu? Eğer mühendiste bir sanatçı bakış açısı yoksa nasıl olacak. Öğrencilerimize estetik anlayışını vermeliyiz.

4.3.2.1.3 Interactions and collaborations engaged in STEAM activities

In both camps and the pilot study, a group of two or three science teachers collaboratively crafted their STEAM project. The observations in both camps indicated that, during the activities, teachers got into plenty of interactions and collaborations with their group members and other groups. The interview data's findings showed some corroborating evidence about the types of interactions taking place between groups. For instance, four of the teachers in the first camp and two of the second camp teachers stated in the interviews that there were many sorts of discussions and collaborations between groups throughout the camp. As they described, those interactions and collaborations mainly involved exchanging ideas, opinions, experiences, and problems related to different parts of the project design.

[FC_INT-3]: Not only our group but I also think of our interactions with the groups next to us. For example, we conversed: "my teacher, how did you solve this problem, or how we solved it, try it, or is it not compatible with the use of a different

color?" I don't know; maybe we should get help from the ladies in the more visual parts. Those were important for us.

[FC_INT-3]: Sadece kendi grubumuz değil, yan gruplar ile olan etkileşimlerimizi de düşünüyorum. Örneğin, hocam bu problemi nasıl çözdünüz ya da biz böyle çözdük siz de deneyin ya da farklı bir renk kullanımında uyumlu mu değil mi ya da ne bileyim daha görselliğe dönük kısımlarda bayanlardan yardım alabiliriz. Bunlar önemliydi bizim için.

While conversing with other groups, teachers, at the same, got a chance to have some interactions with the type of design they crafted. More specifically, they walked around the camp environment to see how good the other design models were, and the well-crafted designs they encountered inspired them to put more effort and works on the next STEAM project.

[SC_INT-4]: We mostly exchanged ideas about the art aspect. We looked at the other groups to see what they do, how they do it, and how we can do it. Those were mostly in regards to art.

[SC_INT-4]: Biz en çok sanat kısmında fikir alışverişinde bulunduk. Diğer gruplara baktık neler yapıyorlar, nasıl yapıyorlar, biz ne şekilde yapabiliriz diye. Yani en çok sanat kısmı.

[FC_INT-2]: You take different things from everyone. Everyone saw each other's product and changed their product accordingly. For example, simpler desings were created initially, but then everyone turned to three dimensions because there was a bar rising.

[FC_INT-2]: Herkesten farklı şeyler alıyorsunuz. Herkes birbirinin ürünün gördü ve kendi ürününü değiştirdi. Mesela ilk başlarda daha basit şeyler yapılıyordu ama sonra herkes üç boyuta döndü çünkü orada çıta yükseliyordu.

As for the interaction and collaboration within groups, all ten of the science teachers in the interview agreed that the STEAM activities encouraged groups to interact and collaborate. Moreover, teachers explained that the interactions and collaborations helped them discuss and exchange ideas, opinions, experiences, and problems related to the project design and negotiate for agreement with group members.

[SC_INT-3]: At first, we brainstormed, thought about how we could improve the design, and discussed the design steps. In the beginning, without doing anything, we made modifications to our

design by just using pencil and paper. My groupmate told me his ideas; I told him my thoughts, and we tried to select and make common points, which made it possible for the group to present its project design. In other words, the final result was not only the product of one person but the product of two persons. We tried to be a bit more democratic because the project design resulted from a collaborative effort. We kept going that way. One of us in the group helped the other who got stuck, and vice versa, so it turned out what group work meant.

[SC_INT-3]: İlk başta beyin fırtınası yaptık, bunu nasıl geliştirebiliriz, işlem basamakları üzerinden tartıştık. En başta hiç bir şey yapmadan kalem kağıt üzerinde tasarımımız üzerinde oynamalar yaptık. Grup arkadaşım kendi fikirlerini söyledi ben kendi fikirlerimi söyledim ve bunlardan ikimize ortak gelen noktaları seçip yapmaya çalıştık. Bu da zaten grubun ürününü ortaya koymasına sebep oluyor. Yani sadece 1 kişinin ürünü değil, 2 kişinin ürünü. Bir kısmında onun, bir kısmında benim emeğim var; onun birleşimi haline geldiği için biraz daha demokratik olmaya çalıştık. O şekilde ilerledik. Birimizin takıldığı noktada diğerimiz yardımcı oldu, böylelikle grup çalışmasının ne demek olduğu ortaya çıktı.

4.3.2.2 The components of the activity sheet

This part describes science teachers' opinions and experiences regarding the content of STEAM activities. This part's findings are reported below under five sections: activity scenario, circuit diagram, design thinking stages, overall content structure, and target group.

Activity scenarios

In STEAM activities, an activity scenario describes a problem situation or case by telling a story. The teachers' groups were expected to come up with the best design as a solution to the problem described in the activity scenario. All ten of the teachers interviewed in the first and second camps stated that it was necessary and essential to integrate an activity scenario into the STEAM activities. From their perspectives, the activity scenarios in the STEAM activates were explicit and well-explained.

[FC_INT-3]: There should be scenarios significantly to increase and improve the student's authenticity. To produce original and different ideas, we have to put forward a problem-based scenario. If the student does not feel to be in a problem-based situation, he/she will not want to solve the problem. The scenario is indeed an important link to the progress of the activity.

[FC_INT-3]: Senaryolar olmalı, özellikle öğrencinin özgünlüğünü arttırabilmek ve geliştirmek adına. Özgün ve farklı fikirler ortaya çıkarabilmek için ortaya bir senaryo koymamız şart. Öğrenci kendini problem içinde hissetmezse haliyle problemi çözmek de istemeyecektir. Senaryo gerçekten etkinliğin yapılabilmesi için önemli bir bağlantı.

[SC_INT-2]: The activity must be based on a problem. That's is why I liked the activities very much. At school too, we can go through a problem because students learn by solving problems. So, this part fits well.

[SC_INT-2]: Etkinlik kesinlikle bir probleme dayandırılmalı, onu çok beğendim. Ben de okulda öyle vermeye çalışıyorum, bir problem üzerinden gitmeyi seviyorum çünkü çocuklar problem çözerek öğreniyor. O nedenle o kısma uygun.

Besides, teachers attributed some positive characteristics to the activity scenarios. They expressed that the activity scenarios' content was excellent, well-written, and elaborating on the problem situation. In addition to that, they thought the activity scenarios were intriguing and corresponding to daily life situations or real-world problems.

[SC_INT-4]: The scenarios suited to everyday life and were good. A phase of curiosity happened there, where the student could put himself in the characters' place in scenarios. I noticed this in our sixth activity, the thermometer activity. So, in the thermometer activity scenario, a problem-based story is described, and the student would get enthusiastic about how to do it. Doing activities this way can motivate the student.

[SC_INT-4]: Günlük hayata uygun olmuş, kesinlikle güzeldi. Orada bir merak uyandırma aşaması oldu, çocukta kendini oradaki öğrencinin yerine koyabilir. Son yaptığımız 6. etkinlikte bunu fark ettim. Yani termometre etkinliğinin senaryosunda bir olay anlatılıyor öğrenci de ben de bu şekilde yapabilirim diye hevesli olur. Bu öğrenciyi motive edebilir.

[FC_INT-2]: As I said before, I liked the scenarios. The way they are scripted is wonderful. The topic and body sentences are very nice. It can be discussed to put a title on the scenarios. I like the scripts pretty much.

[FC_INT-2]: Senaryoları az önce de söylediğim gibi çok beğendim. Yazılış şekilleri çok güzel. Giriş ve gelişme çok güzel. Hatta senaryonun üzerine de başlık konuşulabilir. Senaryoları ben bayağı beğendim.

Circuit diagram

The circuit diagram depicts the connection of sewable electronic components in the circuit to be sewed and stitched into the STEAM project design. The findings showed that most teachers regarded the circuit diagram as a valuable and crucial part of the STEAM activities. Three of the teachers in both the first and the second camp expressed that it was necessary and useful to attach the circuit diagram to the activity sheet. Additionally, two teachers from the first camp stated that the circuit diagram was clear and helpful during the design process.

[SC_INT-3]: Providing a sample circuit diagram was very helpful because it is necessary to have a basic knowledge of electronics to create the circuit diagram. It would be a bit of a dream to expect the middle school student to have that knowledge. So, I'm definitely in favor of giving the circuit diagram. It can be given at least in the first activities and then faded a bit more afterward.

[SC_INT-3]: Örnek devre şemasının verilmesi çok yardımcı oldu gerçekten çünkü devre şemasını oluşturmak için temel bir elektronik bilgisine sahip olmak gerekiyor. Ortaokul öğrencisinin o bilgiye sahip olmasını beklemek biraz hayalcilik olur. O yüzden devre şemasının kesinlikle verilmesinden yanayım. En azından ilk etkinliklerde verilip diğer etkinliklerde biraz daha serbest bırakilabilir.

[FC_INT-6]: Circuit diagram helped us in the design process. The circuit diagram could be modified aesthetically, but still, it was very useful as a scheme.

[FC_INT-6]: [Devre şeması] tasarım sürecinde yardımcı oldu. Estetik olarak değiştirilebilir ancak şema olarak faydalı tabi.

The observations from both the first and second camps showed that some groups made mistakes while connecting circuit components, even with the circuit diagram in front of them clearly showing how the circuit components should be connected. When those groups were informally asked why you made such mistakes with the circuit diagram in your hand, they commonly said that it was likely to make such kinds of errors because we were entirely unfamiliar with e-textile technologies and how they are attached with conductive thread.

Design thinking stages

In both camps, science teachers were instructed to stick rigidly to seven design stages, adapted to the present study's context, while crafting their STEAM projects. It was observed that there were differences among groups of teachers due to adhering to the specified design thinking stages during their project design. While some groups made their project design following the design thinking stages, the other groups unconsciously diverged from it and improvised the entire design process (just used the way they wanted to follow). Furthermore, the findings showed that a vast majority of teachers (five teachers from the first camp and three teachers from the second camp) expressed in the interviews that they considered design thinking stages a practical and beneficial follow-up guideline to organize the design process. For example, one of the teachers said that since we initially did not follow the design thinking stages, some problems arose from the last activities' circuit components. He added that the reason to face those problems was because of not sticking to the steps.

> *[SC_INT-2]: We have never mentioned design-oriented thinking steps here, but we have implicitly used them. At first, we drew our design. We encountered problems, and then we did our design again. A product came into existence. We learned both the engineer design process and the aesthetic design process, but we knew it implicitly. It wasn't because of the follow-up steps, but the techniques like planning, designing, testing, modifying, or improving already became automatic for us. I think that people go into these processes automatically when the problem scenario is appropriate.*
>
> *[SC_INT-2]: Burada tasarım odaklı düşünme basamaklarından hiç bahsetmedik ama örtülü olarak bu basamakları tek tek kullandık. İlk başta tasarımımızı çizdik. Problemlerle karşılaştık, yeniden yaptık. Bir ürün ortaya çıktı. Hem mühendis tasarım*

süreci hem de estetik tasarım süreçlerini öğrendik ama örtülü olarak öğrendik. Şu basamaktan sonra bu basamak var diye değil, planla, tasarla, test et, değiştir ya da geliştir basamaklarını zaten otomatikti bizim için. Problem senaryosu uygun olduğu zaman insanlar o sürece otomatik olarak giriyorlar diye düşünüyorum.

[FC_INT-2]: We have followed all of the design-oriented thinking steps. You said we weren't following, but we were. They were outstanding. It is very important to create a design schema. Making a drawing of the design at first and reading the script is very important. In fact, we have always adhered to scenario-oriented phases. We did what was given. Other groups' creative things overshadowed our design. The design-oriented thinking steps were beautiful. I have also written it in the booklet: since it is related to scientific research methods, I think it was great in serving as an introduction to gain the scientist's characteristics. Putting what you think into a shape and using it for a purpose is essential, though.

[FC_INT-2]: Biz [tasarım odaklı düşünme basamaklarının] hepsini izledik. Siz izlemediğimizi söylediniz, ama izliyorduk. [Tasarım odaklı düşünme basamaklarının] çok güzeldi. Şema oluşturmak çok önemli. Başta çizimini yapmak, senaryoyu okumak çok önemli. Hatta biz hep senaryo odaklı çalıştık, ne veriliyorsa onu yaptık. Diğer gruplar daha yaratıcı şeyler yaptığı için bizim tasarımımız gölgede kaldı. Senaryo basamakları güzeldi. Kitapçığa da yazdım, hatta bilimsel araştırma yöntemleri ile alakalı olduğu için bilim insanı özelliklerini kazandırmaya giriş olması açışından çok güzeldi bence. Çünkü düşündüğünü şekle döküp geçirmek ve bir amaca uygun kullanmak hepsinden önemli şeylerdir.

Each design thinking stage included specific instructions to guide the designer during the STEAM project design process. According to one of the first camp teachers, the instructions given under each design thinking stage were suitable and appropriate for the middle school level. More specifically, teachers thought that following design thinking stages would help students put the whole design process in order, organize the sequence of the actions they were required to make in time, and explore the consequences of their actions as failure or success.

[FC_INT-5]: Certainly, the student will plan, draw the prototype, provide the material according to it, and then apply it. The best part of the cycle is that: it makes you return to the back

when you mistake and learn from that mistake. In other words, students will make mistakes voluntarily and have the chance to correct them again.

[FC_INT-5]: Kesinlikle öğrenci de planlayacak, prototipini çizecek, sonra materyalini ona göre temin edecek, ondan sonra da uygulayacak. Döngünün en güzel tarafı şu: hata yaptığınızda sizi başa döndürmesi ve hatadan öğrenmesini sağlaması. Yani çocuklar özgür bir şekilde hata yapacaklar ve bu hatalarını tekrardan düzeltme şansına sahip olacaklar.

Overall content structure

Science teachers were probed to talk about the general design of the STEAM activities they engaged in during the camp. The findings showed that most of the teachers interviewed were quite satisfied with the quantity and quality of the content of the STEAM activities. For example, three of the first camp teachers expressed in the interviews that the activities' content and the way they were designed were adequate for us and would be sufficient for students. Several teachers also got some constructive and sensible suggestions for developing the content.

[FC_INT-4]: I think the content was generally sufficient; that is to say, I did not have any trouble. It was even very simple to us. Yes, it made me feel that the content was just fitted to the level of a child. I found the main idea after reading the content. Of course, the student would also need to read a little to understand it, but once I have read the main idea, I say, okay, I will do it.

[FC_INT-4]: Bence içerik genel olarak yeterliydi, yani ben zorlanmadım. Hatta çok da basit geldi bize. Evet, tam da böyle çocuk düzeyinde gelmiş gibi geldi bana, öyle hissettirdi. Okuduktan sonra verilen düşünceyi buluyordum. Tabii çocuk da anlamak için biraz okuyacak, ama ben hemen ana fikri okuyorum ve tamam ben bunu yapacağım diyorum.

The qualitative and quantitative data analysis showed that a great number of teachers didn't have difficulty following, reading, and understanding the directions and explanations given for the STEAM activities. Moreover, most of the teachers found STEAM activities straightforward and easy to implement. Five of the teachers in the first camp and all four of the second camp teachers stated in the interviews that the instructions and explanations given in each activity were straightforward and adequate to navigate and steer the crafting of their project design to the final phase. Moreover, they expressed it would be easy for students to make the STEAM activities thanks to these instructions and explanations provided in each activity sheet. The same view was also reflected in one of the teacher's responses to the group open-ended questions in the second camp.

> *[FC_INT-5]: For students, maybe something can be done like enlarging images a little bit, but in general, I think it was enough. That is to say, the instructions were unambiguous, and the drawing lines were very descriptive. All in all, I liked the activities very much, and they were excellent.*
>
> *[FC_INT-5]: Öğrenciler için belki şey olabilir hani görseller belki biraz daha büyültülebilir ama ben genel olarak yeterli olduğunu düşünüyorum. Yani yönergeler çok açıktı, çizgiler gayet açıklayıcıydı. Genel olarak etkinlikleri ben çok beğendim ve çok iyiydiler.*
>
> *[SC_INT-2]: The guidelines were clear enough and would also be sufficient for the students. Everything has been thought down to the finest detail.*
>
> *[SC_INT-2]: Yönergeler gayet açıklayıcıydı ve öğrenciler için de yeterli olacaktır. Her şey en ince ayrıntısına kadar düşünülmüş*
>
> *[SC_GR_OE-4]: The guidelines were straightforward and understandable.*
>
> *[SC_GR_OE-4]: Yönergeler net ve anlaşılırdı.*

Related to the characteristics of content structure, two of the teachers in the first camp and three of the second camp teachers expressed in the interviews that, overall, STEAM activities were carefully-designed and well-organized in terms of the content. The content structure allowed teachers to easily follow the directions and understand the featured parts throughout the activity process. Additionally, teachers were convinced that even middle school students wouldn't struggle to read, understand, and follow the content. According to them, the content of existing STEAM activities could be easily applied in the school with its current form.

> *[FC_INT-4]: The content of the activities was good for me. I was able to explain what I was reading.*

[FC_INT-4]: Etkinliklerin içeriği benim açımdan güzeldi. Açıklayıcıydı aslında okuduğumu açıklayabildim.

[SC_INT-1]: I think the content of the activities is very well prepared. At first, it pushed us a little bit because we saw things that we had never experienced before. We had difficulties, especially in sewing, but then we realized that one could do it once he got used to it and felt ready for it next time. It was a good camp full of content.

[SC_INT-1]: Etkinliklerin içeriğinin çok güzel hazırlandığını düşünüyorum açıkçası. Başta biraz bizi zorladı çünkü daha önce hiç karşılaşmadığımız şeylerle karşılaştık. Özellikle dikim konusunda baya sıkıntı yaşadık. Fakat daha sonra insanın eli alışınca ve kendini hazır hissedince yapabildiğini gördük. İçeriği dolu dolu güzel bir kamptı.

[SC_INT-3]:Regarding the content, the activities are good for middle school students in terms of helping them to complete a simple electrical circuit, recognize LEDs, and identify electronic circuit elements. The activities have content worth to provide effective learning. In this respect, I find them successful in terms of the way they are prepared. In the activity booklet, each step is explained one by one, making it more planned and programmatic, providing a way for the students to learn the scientific process well. When they are going to prepare a project in the future, it will give an idea about what steps they should follow. In that sense, the camp develops both scientific process skills and creativity. I found it quite successful.

[SC_INT-3]:İçerik hakkında, basit elektrik devresi tamamlama, ledleri tanıma, elektronik devre elemanlarını tanıma anlamında ortaokul öğrencileri için güzel etkinlikler. Etkili bir öğrenme sağlayabilecek bir içeriye sahip. Ben bu anlamda etkinliklerin hazırlanış bakımından başarılı olduklarını düşünüyorum. Özellikle hazırlanan kitapçıkta her bir adımın teker teker açıklanması, burada biraz daha planlı ve programlı gidilerek yapılmasını sağlıyor, bu da hem bilimsel süreç basamaklarını iyi öğrenme anlamında öğrencilere de bir yol gösterecektir veya ileride bir proje hazırlayacakları zaman bunu hangi basamaklara göre hazırlamaları hakkında bir fikir veriyor. Bu anlamda hem bilimsel süreç becerileri gelişiyor hem de yaratıcılık gelişiyor. Ben gayet başarılı buldum.

Besides, as indicated in table 4.3, 96.8% of the teachers agreed or strongly agreed that the directions and explanations given for the STEAM activities were clear and understandable. More specifically, most teachers (29% and 61.3% respectively) agreed and strongly agreed that they didn't have difficulty understanding and reading the directions and explanations given for the STEAM activities. Besides, 90.4% of the teachers agreed or strongly agreed that they didn't struggle to follow the activities' guidelines and instructions. Furthermore, it can be seen from the data in Table 4.4 that numerous teachers (29% and 45.2%, respectively) agreed and strongly agreed that they found STEAM activities were easy to do and implement. Likewise, 90.3% of the teachers disagreed or strongly disagreed that they struggled to understand activities due to having difficult content.

Table 4.3 The quality of activity directions

Items	*M*	*SD*	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
The instructions and explanations for the activities were clear and understandable.	6.61	0.56	-	-	-	-	3.23	32.26	64.52
I had no difficulty understanding the instructions and explanations given for the activities.	6.42	1.03	-	3.23	-	-	6.45	29.03	61.29
I had no difficulty applying the instructions and explanations given for the activities.	6.45	0.77	-	-	-	3.23	6.45	32.26	58.06

Table 4.4 Ease of doing activities

Items	*M*	*SD*	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
It was difficult to do the activities in the camp.	2.23	1.26	38.71	25.81	12.90	19.35	3.23	-	-
I did not have any difficulty doing the activities in the camp.	5.84	1.68	6.45	3.23	-	-	16.13	29.03	45.16
The activities in the camp were complicated to understand.	1.87	1.77	61.29	29.03	-	-	-	-	9.68
The activities in the camp were easy to do and implement.	5.87	1.59	6.45	-	-	6.45	12.90	29.03	45.16
Students would not have difficulty doing the camp activities.	5.45	1.77	6.45	3.23	3.23	9.68	16.13	25.81	35.48

4.3.2.3 Design principles for the implementation of the STEAM activities in the camp

A STEAM camp should be equipped with as many varieties of materials as possible so that groups of teachers could harness their full potentials and skills. It should be noted that some of the wearable e-textile technologies, especially the Lilypad Arduino board, are fragile and could be easily broken during the project design. Therefore, the number of wearable e-textile technologies in the camp should be increased by at least one-third of the activities' materials. The same ratio should be applied to textile and craft materials as well. It is also crucial to ensure the camp materials' diversity, especially those used for design and crafting. The type of design produced by the groups is unpredictable and may include using different styles and sorts of textile and craft materials.

Since group work encourages interaction and collaboration within and between groups, the STEAM activities should be made in groups rather than individuals because this could facilitate learning and understanding.

There are three critical pillars of STEAM activities: activity scenarios, circuit diagrams, and design thinking stages. Every content of a STEAM activity should include at least these three components.

The STEAM activities' overall content, including the directions and explanations, should be clear, simple, and straightforward. Additional details, confusing words and phrases, and misleading descriptions should be avoided to use while designing and developing a whole activity content. Also, the level of the language used in the activity content should be kept as simple as possible so that anyone who reads the content could understand the same thing.

4.4 Teachers' transfer of STEAM camp training outcomes in their courses

This section reports findings on teachers' ability to transfer what they learned and experienced in the camp to the classroom. The following subsections provide details on these findings.

4.4.1 Integration of STEAM activities into the science curriculum

This section describes science teachers' reflections on the possibility and necessity of integrating or incorporating STEAM activities into the science curriculum. The analysis of teachers' responses to interview and survey questions showed that most teachers believed that STEAM activities could be integrated into middle schools' science programs. Three of the first camp teachers and four of the second camp teachers expressed in the interviews that it was highly possible to integrate STEAM activities into the science curriculum. The same view was reflected in the survey data that was collected at the end of the camp. As can be seen from the Table 4.5, many teachers (19.35% and 74.19% respectively) agreed and strongly agreed that "STEAM-focused e-textile activities should be integrated into the curriculum."

Table 4.5 Transfer of knowledge and experiences

items	*M*	*SD*	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
I can apply what I learned in the camp in my school.	6.29	0.94	-	-	-	6.45	12.90	25.81	54.84
I consider myself competent enough to transfer the knowledge and skills I learned in the camp to my students.	6.19	1.22	3.23	-	-	-	16.13	29.03	51.61
I can benefit from wearable e-textile technologies to teach electricity concepts in my lessons.	6.52	0.51	-	-	-	-	-	48.39	51.61
I developed the ability to utilize STEAM-focused e-textile activities to teach electricity concepts.	6.45	0.62	-	-	-	-	6.45	41.94	51.61
STEAM-focused e-textile activities should be integrated into the curriculum.	6.65	0.71	-	-	-	3.23	3.23	19.35	74.19
Through the knowledge and skills, I learned in the camp, I can design similar activities using wearable e-textile technologies.	6.71	0.46	-	-	-	-	-	29.03	70.97
With what I learned in the camp, I can use wearable e-textile technologies in different fields.	6.65	0.55	-	-	-	-	3.23	29.03	67.74
I can adequately transfer the art dimension to my STEAM-focused e-textile designs.	5.68	1.25	-	3.23	-	12.90	25.81	25.81	32.26

Furthermore, teachers who favored the integration called for changes to STEAM activities and mentioned some barriers to the integration process, which were addressed in the challenges part. Consequently, despite the challenges facing the integration process, STEAM activities can still hold excellent potentials ready to be exploited by schools.

> *[FC_INT-4]: The activities should be integrated. Theoretical knowledge does not bring anything; it is forgotten in time. Since the students are active here, they learn the knowledge by themselves, realize the problems, feel responsible in exploring the solution, and use their skills. Here, they perhaps apply things that they have never done before.*
>
> *[FC_INT-4]: [Etkinlikler] kesinlikle entegre edilmeli. Teorik bilgiler birşey kazandırmıyor, zamanla unutuluyor. Burada öğrenciler aktif olduğundan bilgiyi kendi öğreniyor, problemleri farkediyor, cözümünde kendini sorumlu hissediyor ve becerilerini kullanıyor. Belkide hiç yapmadığı şeyleri burada kullanıyorlar*
>
> *[FC_INT-3]: The activities can be integrated into the science course, and they are also applicable, funny, and useful applications.*
>
> *[FC_INT-3]: [Etkinlikler fen dersine] entegre edilebilir; kullanışlı, eğlenceli ve faydalı uygulamalar.*
>
> *[SC_INT-1]: Since many of the activities we do in constructivist education are similar to STEAM activities, they can be integrated into the classroom.*
>
> *[SC_INT-1]: Yapılandırmacı eğitimde de bir çok yaptığımız etkinlikler buna benzer olduğu için STEAM etkinlikleri de entegre edilebilir.*

4.4.2 Perceived ability to implement activities in classroom

After engaged in designing art-focused STEAM projects, science teachers were asked how they thought they could implement those activities in the school. Many science teachers appeared to be very enthusiastic about enacting STEAM activities in school. They were also convinced that implementing STEAM activities in the classroom would considerably help students acquire knowledge of science subjects and other fields' competencies. All the teachers from the first and second camps expressed in the interviews that they could implement STEAM activities in their school. The same thought was also reflected in the responses to the open-ended questions by three teachers from the first camp and a teacher from the second camp. Additionally, it can be seen from the data in Table 4.5 that about 80.6% of teachers agreed or strongly agreed that they could apply STEAM activities in their school or relevant settings. Similarly, 28.6% and 52% of teachers, respectively, agreed and strongly agreed that they considered themselves competent and sufficient to transfer the knowledge and skills they had acquired in the camp to the classroom.

> *[FC_GR_OE-2]: Yes, I think I can transfer all of them to my classes.*
>
> *[FC_GR_OE-2]: Evet tamamını derslerime aktarabileceğimi düşünüyorum.*
>
> *[SC_GR_OE-1]: If there is an opportunity to gain experience and get the materials, these activities can be applied in the classroom.*
>
> *[SC_GR_OE-1]: Deneyim ve malzeme imkanı olursa gayet kullanilabilir ve uygulanabilir etkinliklerdir.*
>
> *[FC_INT-2]: Let's say I'm eager to implement it, I'm looking for an opportunity. I can implement it, but as I said, we have a limited financial budget in the public school.*
>
> *[FC_INT-2]: Uygulamak için hevesliyim, fırsat kolluyorum diyelim. Uygulayabilirim, ama bunun için dediğim gibi devlet okulunda kısıtlı finansal bütçe hadisemiz var bizim.*

However, there was a difference between the teachers' opinions regarding the type of course that would be more suitable to implement STEAM activities. The teachers who endorsed the elective course over the science course thought they might not implement the activities in a science course due to factors like time constraints, overcrowded classrooms, inappropriate space, etc. However, they felt they could implement them in an elective course instead.

> *[FC_INT-4]: I will apply the activities. I may not do it in my class, but I can apply them in an elective course like a science practice course. I have to teach the course topics in the must course, and I cannot find the required materials to do activities with the*

students. I can do activities like preparing instructions, putting them in front of the students, and implementing them in groups. They can start every week from where they left off. If I do these things, they will be much more successful. However, while teaching the must course, it would be challenging to teach the course subject and do the activities concurrently.

[FC_INT-4]: Kesinlikle yapacağım. En azından dersimde yapamayacağım ama bilim uygulamaları dersi gibi seçmeli bir ders alırsam yapabilirim. Çünkü ana derste ders anlatmak zorunda kalıyorum ve çocuklarla etkinlik yapmak için malzeme bulamıyorum. Yönergeler hazırlayıp öğrencilerilerin önüne koymak ve onları grup yapmak tarzında çalışmalar yapabilirim. Her hafta kaldıkları yerden devam ederler, bunlar aklıma şimdi geldikçe söylüyorum. Bunları yaparsam çok daha başarılı olurlar, ama ana dersi öğretirken, hem konuyu anlatıp hem de böyle bir etkinlik yapmak inanın çok zorlar.

[SC_INT-4]: I can definitely apply the activities; I can apply them all. After learning to connect the circuit and sewing it in the first activity, all the remainings can be applied step by step. But it can only be implemented in science applications courses, not in the must course. It is hard to implement them in a science course due to the limited course time and crowded classroom. Otherwise, they could be applied in the science course as well. In fact, it would be great to make some of the activities in the classroom and then give projects to the students.

[SC_INT-4]: Yüzde yüz uygulayabilirim, hepsini uygulayabilirim. Çünkü ilk etkinlikte devre bağlamayı, dikmeyi öğrendikten sonra aşama aşama hepsi uygulanabilir. Ama derste değil de bilim uygulamaları dersinde olabilir. Fen dersinde uygulamak zor. Zaman ve kalabalık ortamdan kaynaklı, yoksa yine uygulanır. Hatta biraz uygulanıp çocuklara proje ödevi vermek harika olur.

The schedule for the science course in the school may not permit to make STEAM activities and teaching practice at the same time. The reason is that, in a traditional science course, science teachers generally devote a vast amount of the course time to giving students theoretical knowledge on various science concepts. That’s why teachers may not apply activities in the course period. Instead, as teachers stressed, they could compensate it with the elective courses.

[SC_INT-1]: I am definitely thinking of applying these activities in the 7th and 8th-grade levels. I have even looked at the prices of

the materials right now. I believe that such a thing will be very positive in every aspect of the science applications course.

[SC_INT-1]: 7. ve 8. sınıflarda kesinlikle uygulamayı düşünüyorum. Yani ben şu an malzeme fiyatlarına bile baktım. Bilim uygulamaları dersinde özellikle böyle bir şeyin her açıdan çok olumlu olacağını düşünüyorum.

The survey result demonstrated that teachers were convinced that they could develop STEAM-like activities in different fields and settings using wearable e-textile technologies. For example, all thirty-one of the teachers agreed or strongly agreed that they could prepare learning activities similar to those they engaged in the camp. Similarly, all teachers (100%) agreed or strongly agreed that the knowledge and skills they acquired from the STEAM training camp would help them to exploit wearable e-textile technologies in different fields (see Table 4.5).

4.4.3 Transferring of knowledge and skills into the school setting

Science teachers were asked to indicate the extent to which they can transfer the knowledge and skills they have grasped in the camp into the school setting. The analysis of teachers' responses to interview and survey questions revealed that many teachers think they can transfer the camp learnings and experiences to the classroom and share them with students. All of the teachers interviewed in the first and the second camp expressed that they could successfully transfer what they had experienced and gained in the camp to the school environment. A total of six teachers said that even if they had acquired sufficient camp experiences and knowledge for making activities in the school, that wouldn't be possible unless their access to the activity materials was guaranteed. Furthermore, the survey result showed that many teachers thought they could integrate camp knowledge and experiences into teaching practice. As indicated in Table 4.5, 48% and 52% of the teachers agreed and strongly agreed that they could use e-textile technologies to teach electricity concepts in their classroom.

[FC_INT-1]: I can transfer them all.

[FC_INT-1]: Hepsini aktarabilirim.

[SC_INT-4]: I think that I can transfer them all.

[SC_INT-4]: Hepsini aktarabileceğimi düşünüyorum.

[SC_INT-3]: We took photos and videos of our activities to excite the students and provide them with a new perspective. In the first place, I will show them to the students, and at least we can set goals for students to see what a university environment resembles. Doing this makes the students a little ambitious, especially 8th-grade students, not those at 5th,6th, and 7th grades, because since they are still at game age, the activities could be meaningless to them. Even if I could not get the students to do the activities, I can buy some of the materials with our resources and demonstrate how to design them. In the subject of electricity, instead of just sticking the switch, battery, and light bulb on the board, I plan to show the students the sewable circuit elements, which we have learned here in the camp, in the application course.

[SC_INT-3]: Öğrencileri heyecanlandırmak, onlara yeni bakış açısı sağlamak anlamında tabi ki yaptıklarımızın fotoğraflarını, videolarını çektik. En başta öğrencilere onları göstereceğim en azından bir üniversite ortamının nasıl olduğunu görmeleri açısından onlara hedefler gösterebiliriz. Bu öğrencileri biraz hırslandırıyor açıkçası. Özellikle 8. sınıf öğrencilerini, 5-6-7 lerde biraz daha oyun çağından hala kurtulamadıkları için onlara biraz anlamsız geliyor ama 8. Sınıfları heyecanlandırıyor. Öğrencilere yaptıramasam bile kendi imkanlarımız ile aldığımız bazı malzemeleri kullanarak gösterebilirim. Elektrik konusunda artık sadece anahtar, pil, ampulü tahtanın üzerine yapıştırmaktansa, burada öğrendiğimiz dikilebilir devre elemanlarını göstermeyi özellikle uygulama dersinde yapmayı düşünüyorum.

They also added that the camp provided an excellent opportunity to get essential information about the STEAM activities and how they are crafted. They thought that the crucial information and fruitful experiences they gained from making STEAM activities would help them develop different ideas and grow their knowledge base beyond the current level.

[FC_INT-4]: I would apply the activities in the subject of electricity. I can apply a simple electrical circuit with these technological materials. I need to improve myself a little more. Maybe I need to learn different activities, but I got the fundamental experience, that is enough. The rest is up to me. Adding other ideas

etc., varies by person. I think anyone who has essential knowledge and skill can apply it.

[FC_INT-4]: Elektrik konusunda kendim uygularım. Basit bir elektrik devresini bu teknolojik malzemelerle uygulayabilirim. Kendimi biraz daha geliştirmem lazım. Belki farklı etkinlikler öğrenmem lazım ama alt yapıyı aldım bu yeterli olur. Gerisi bana kalmış olur. Değişik fikirler katmak vs. bunlar kişiye göre değişir. Altyapı olduğu için bence herkes bunu uygulayabilir diye düşünüyorum.

In addition to qualitative data analysis, the analysis of survey data showed that teachers already had some plans to improve what they have learned and experienced during the camp and transfer their learning beyond the classroom to new problems and settings. For instance, as shown in Table 4.6, all teachers (29% and 71% respectively) agreed and strongly agreed that they were planning to develop further their camp knowledge and learning. Similarly, all thirty-one of the teachers (29% and 71% respectively) agreed and strongly agreed that they were already planning to develop new projects using the knowledge they gained from the camp. Similarly, a total of 77.6% of the teachers agreed or strongly agreed that they would do STEAM-like hands-on projects with students using the camp knowledge and experiences (see Table 4.6).

Table 4.6 Future prospects and plans

items	M	SD	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
Similar camps should be organized frequently.	6.90	0.40	-	-	-	-	3.23	3.23	93.55
I would love to participate in this or similar training camps again.	6.77	0.50	-	-	-	-	3.23	16.13	80.65
Similar training camps should be organized as in-school activities.	6.52	1.00	-	3.23	-	-	3.23	25.81	67.74
I plan to make new projects with my students with the knowledge I gained at the camp.	6.61	0.62	-	-	-	-	6.45	25.81	67.74
I plan to improve the skills I acquired at the camp.	6.71	0.46	-	-	-	-	-	29.03	70.97
I plan to develop new projects in line with the knowledge I gained at the camp.	6.81	0.40	-	-	-	-	-	19.35	80.65

4.4.4 After-camp evidence regarding the implementation of STEAM activities in different settings

A one-page survey form with five open-ended questions was mailed to teachers who have participated in the STEAM camp to learn where and how they transfer the knowledge and skills they have gained in the camp to different contexts. Four teachers, two from the first camp and two from the second camp, responded that they had applied some camp activities with their students as part of a science course. One of the first camp teachers also stated that he would soon implement the STEAM camp program with 6th and 7th-grade students in his upcoming Erasmus project.

> *[FC_PT-1]: So far, I have applied some of the activities in an electrical circuit unit for 5th-grade students in middle school. However, in the 2018-2019 academic year, I will implement all of these activities with 6th and 7th-grade students in a course that will last about three months within the Erasmus project scope*
>
> *[FC_PT-1]: Şu ana kadar ortaokul 5. sınıf öğrencileri ile elektrik devre elemanları ünitesi için uyguladım. Ancak 2018-2019 eğitim–öğretim yılı içerisinde Erasmus projesi kapsamında yaklaşık 3 ay sürecek bir kurs ile 6. ve 7. sınıf seviyelerinde bu etkinlikler uyulanacaktır.*

One of the second camp teachers organized a science fair in this school, together with other teachers from different fields. In the event, he designed four hands-on activities with five grade students and their parents using his knowledge and experiences, and resources from the STEAM camp. The activities they created included a badge, wristband, necklace, and color-changing scarf. He added that students had a lot of fun and learned the electric circuits very well.

> *[FC_PT-2]: I organized a TUBITAK science fair. I prepared 20 projects with my colleagues in the department, including bracelets, necklaces, rosettes, and color-changing scarves. 5th-grade students had fun and learned a lot. They understood the electrical circuit very well thanks to these activities.*
>
> *[FC_PT-2]: Tübitak bilim fuarı düzenledim. Zümredeki öğretmen arkadaşımla beraber 20 proje hazırladık. Bileklik, kolye, rozet ve renk değiştiren fular tasarladık. 5.sınıf öğrencileri çok eğlendi ve öğrendiler. Elektrik devresini gayet iyi anladılar bu uygulama sayesinde.*

The teacher also stated that student parents' reactions to the activities were noteworthy. They expressed their surprise and said that they didn't have such projects when they were students. According to the teacher, parents acted as if they were students while working with their children on the project design.

> *[FC_PT-2]: Together with the students, we did the activities we had done in the STEAM training camp. The parents of the students were amazed. The parents expressed their astonishment: "There*

were no such projects in our student years." Parents became students with their children, worked at home, and helped their children. The electric circuit and the subject of electricity became more understandable. These activities are beneficial for making electric circuits intriguing.

[FC_PT-2]: Modak kampında yaptığımız etkinlikleri öğrencilerle birlikte yeniden yaptık. Öğrenci velileri çok şaşırdı. Veliler "Bizim öğrencilik yıllarımızda böyle projeler yapılmıyordu" şeklinde şaşkınlıklarını dile getirdiler. Veliler de çocuklarıyla birlikte öğrenci oldular ve evlerinde uğraştılar, çocuklarına yardımcı oldular. Elektrik devresi ve elektrik konusu daha anlaşılır oldu. Bu etkinlikler elektrik devrelerini sevdirmek için çok faydalı.

All four of the teachers reported that their camp learning and experiences become very useful during the implementation of STEAM activities. One of the first camp teachers added that students completed their projects with great desire and pleasure. They reported that they didn't have any trouble with the project circuit except for some coding problems.

[FC_PT-1]: I did not encounter any problems, especially with the creation of circuits from sewable electronics. In this aspect, I can say that the camp met the educational need for e-textile technologies. Yet, I had problems with Arduino coding. During the activities, students completed their projects with great enthusiasm and pleasure.

[FC_PT-1]: Özellikle devrelerin kurulması açısından herhangi bir problemle karşılaşmadım. Bu yönüyle verilen eğitim ihtiyacını karşıladı diyebilirim. Ancak Aurdino ile kodlama ile ilgili sorunlar yaşadım. Etkinlikler sırasında öğrenciler büyük bir istek ve zevkle projelerini tamamladılar.

One of the teachers from the second camp also had problems with coding during the practice. He complained that he could not apply the camp activities with their students due to the school's lack of funds. Instead, he implemented some of the activities through his efforts. Furthermore, in his informal chat with the researcher, the teacher expressed that despite his initiative to involve teachers from other disciplines in preparing the activities, none indicated an interest in participating.

[SC_PT-2]: I learned about electronics and coding. I am trying to implement activities with my means, but I am having trouble at the

point of coding. I also cannot apply the activities in the classroom due to a shortage of allowance at school.

[SC_PT-2]: Elektronik ve kodlama hakkında bilgi edindim. Kendi olanaklarımla uygulamalar yapmaya çalışıyorum. Ancak kodlama noktasında sıkıntılar yaşıyorum. Ayrıca okulda ödenek sıkıntısından dolayı öğrencilere uygulatamıyorum.

Teachers were asked to describe the changes and revisions they made to the existing camp program or activities. Teachers' responses to the question indicated that only two of the teachers made revisions to the current STEAM activities. For example, one of the teachers explained that students' low cognitive development and ignorance of robotic made him ease the hand-making and technical tasks associated with the activities.

[SC_PT-2]: Students' developmental level is deficient, and they profoundly lack knowledge about robotics. I've pushed myself too far to do something without school facilities and means. As far as I could, I transferred the camp activities to the students by making it more straightforward, i.e., by making muscle skills and technical work lighter.

[SC_PT-2]: Çocukların gelişim düzeyleri ve robotik hazır bulunuşlukları çok düşük. Bir şeyler yapmak için okul imkanları dışında kendimi çok fazla zorladım. Yapabildiğim kadarıyla Modak etkinliğini daha basit hale getirerek yani kas becerisi ve teknik işleri daha hafif hale getirerek öğrencilere aktardım.

The other teacher turned existing science units into a STEM unit at the class level. He planned the activities in line with unit objectives and content and then implemented them following the engineering design process. It seems that he extracted relevant purposes from the science units and integrated them into the hands-on STEAM activities. Still, he adhered to design thinking stages while applying the activities.

[FC_PT-1]: I have transformed the existing science units into a STEM unit to match class level. I planned the activities in line with the unit's objectives and content and taught the lessons based on the engineering design cycle. Although there are no serial and parallel circuits in the 5th-grade electrical circuit elements unit, I included the activities' circuit-related objectives. Besides, there

was no restriction on the product design. The students created a prototype of a product they designed.

[FC_PT-1]: Mevcut fen bilimleri ünitelerini sınıf seviyesinde bir STEM ünitesine dönüştürdüm. Ünitenin kazanımları ve içeriği doğrultusunda etkinlik planladım ve mühendislik tasarım döngüsü temel alınarak dersleri işledim. 5. sınıf elektrik devre elemanları ünitesinde her ne kadar seri ve parelel bağlamalar bulunmasa da düzenlenen etkinlikte bu kazanımlar yer almıştır. Ayrıca ürün konusunda sınırlandırmaya gidilmedi, öğrenciler tasarladıkları bir ürünün prototipini oluşturdular.

4.4.5 Design principles for transferring camp learning and experiences into different contexts

After attending a STEAM camp and engaging in all the hands-on activities, a teacher could acquire the ability and necessary skills to implement the same or similar camp in school or relevant settings. In other words, teachers can implement the camp in their school as long as they have access to the camp materials, including wearable e-textile technologies and crafting tools. Furthermore, a teacher could perform a STEAM camp or the STEAM activities in or out of school, depending on the available time and suitable conditions. For the science teachers, the scheduled course time, which is generally separated for conveying theoretical content knowledge to the students, may not allow them to teach the course and implement the camp simultaneously. Besides, the classroom environment designed specifically for conventional teaching may not be physically appropriate to make the activities. The STEAM training camp does not have to be implemented within the course hours or in the classroom. For example, the amount of time it took to apply the camp activities could be borrowed from other elective courses, and instead of the main course, a more suitable space could be arranged or prepared in advance.

A STEAM camp could give teachers essential knowledge and experiences to apply the same or similar activities in different contexts. However, the camp's proper implementation depends mostly on the degree to which teachers transfer that knowledge and experiences to school settings. Consequently, a teacher could successfully transfer the camp knowledge and skills to the classroom, as evidenced by three teachers who have implemented some of the STEAM activities in class with their students.

4.4.6 The expectations and satisfaction of the science teachers with the camp

During the four-day camp, each day of the teachers was different but always filled with full of actions and activities. Observations in both camps showed that teachers had a perfect and funny time, and most importantly, enjoyed working on their projects, learning new things, and exploring new technologies. In their responses to open-ended questions at the end of the camp, teachers highlighted the parts they most liked and enjoyed in the camp. Furthermore, teachers came to the camp to gain a great deal of knowledge and experience in many areas. Pre and post-open-ended questions measured teachers' expectations of attending the camp and the extent to which those expectations were fulfilled. As a result, this theme is divided into three parts: science teachers' motives for attending the camp, the positive characteristics of STEAM activities, and activities' favorite features.

4.4.6.1 Science teachers' motives for attending the camp

The analysis of responses to the pre-open-ended questions at the beginning of the camp showed that teachers had different motives or reasons for participating in the camp. Teachers' expectations for the camp were divided into seven parts, which all referred to the development of professional knowledge and experiences.

Twelve of the teachers in the first camp and three of the second camp teachers stated that they expected to acquire the necessary knowledge and skills in using art-focused wearable e-textile designs. They explained that the addition of art to the STEM approach appealed more to them. Moreover, they wanted to get involved in STEAM practices and, in turn, develop professional experiences.

[FC_PRE_OE-2]: My purpose in participating in the camp is to increase my knowledge and skills about wearable technologies.

[FC_PRE_OE-2]: [Kampa katılmamın amacı] giyilebilir teknolojiler hakkında bilgi ve beceri düzeyimi artırmak.

[SC_PRE_OE-8]: In the camp, I hope to learn the essential information about wearable technologies in a way that makes my profession easier.

[SC_PRE_OE-8]: Kampta giyilebilir teknolojilerin bilimsel altyapısını uygulamada işimi kolaylaştıracak şekilde öğrenmeyi umuyorum.

Four of the teachers in the first camp and five of the second camp teachers indicated that they came to the camp to catch up with new technologies in the educational settings. Teachers stated that they wanted to get familiarity with modern educational technologies and approaches.

[FC_PRE_OE-7]: I think it will be useful to be aware of the technological developments and innovations in educational programs.

[FC_PRE_OE-7]: Teknolojideki gelişmeler ve eğitim programlarındaki yeniliklerden haberdar olma açısından faydalı olacağını düşünüyorum.

[SC_PRE_OE-11]: In this context, I am here to use technology efficiently in education and keep up with educational innovations.

[SC_PRE_OE-11]: Bu bağlamda eğitimde teknolojiyi verimli kullanmak ve yeniliği takip etmek için buradayım.

Conveying STEAM knowledge, skills, and experiences to school settings was another reason for teachers' participation in the camp. All twenty of the first camp teachers and all fourteen of the second camp teachers reported that they wanted to transfer the camp's learning and experiences to school and share them with their students.

[FC_PRE_OE-20]: Using the information and skills I have learned here, I would educate my students and let them have fun times, and provide them different perspectives.

[FC_PRE_OE-20]: Burada öğrendiğim bilgileri kullanarak öğrencilerime bilgi verirken hem eğitmek ve eğlenceli zamanlar geçirmelerini sağlamak, hem de farklı bakış açısı kazandırmak.

[SC_PRE_OE-10]: My expectation from the camp is to learn wearable technologies at a basic level and adapt them to my classes.

[SC_PRE_OE-10]: Kamptan beklentim giyilebilir teknolojileri giriş seviyesinde öğrenip derslerime adapte edebilmektir.

Six of the teachers in the first camp and seven of the second camp teachers stated that they came to the camp with the expectation of developing and implementing STEAM-like activities. Teachers explained that they wanted to learn how STEAM activities were developed and implemented and then integrate similar activities in their courses.

[SC_PRE_OE-1]: The reason for attending the camp is to develop my science and technology club activities through STEAM activities involving innovative 21st-century skills.

[SC_PRE_OE-1]: [Kampa katılma nedenim] yaptığım bilim teknoloji kulübü çalışmalarını yenilikçi 21. yüzyıl becerilerini içeren etkinliklerle geliştirmek.

[SC_PRE_OE-2]: I expect to increase my programming and STEAM experience at the end of the camp and to be able to use it in my classes.

[SC_PRE_OE-2]: Kamptan beklentim kamp sonunda programlama ve STEAM tecrübemi artırmak ve bunu derslerimde kullanabilecek düzeye gelmektir.

Teachers were motivated to attend the camp to increase the STEAM knowledge base for the projects or prospective national grant programs supported by the Scientific and Technological Research Council (TUBITAK) or Ministry of National Education (MEB). It seemed that teachers came to the camp to gain experiences and knowledge about art-focused STEAM projects and then exploit those experiences and expertise in their prospective educational projects.

[FC_PRE_OE-3]: I plan to gain the information and skills I have learned in camp and use it in TUBITAK projects.

[FC_PRE_OE-3]: Kampta öğrenmiş olduğum bilgileri Tübitak proje çalışmalarında yararlanmayı planlıyorum.

[SC_PRE_OE-2]: I am planning to carry out similar activities within the scope of TUBITAK projects.

[SC_PRE_OE-2]: Tübitak projeleri kapsamında benzer etkinlikler yapmayı planlıyorum.

Eight of the teachers in the first camp and three of the second camp teachers stated that they attended the camp to learn the Arduino programming language and get familiarity with the Arduino development environment. Learning coding seemed to be a motive for the teachers to participate in the camp.

[FC_PRE_OE-10]: My expectations in the camp are to learn more about the Arduino programming language, to use Arduino effectively, and to prepare projects through Arduino.

[FC_PRE_OE-10]: Kampta beklentilerim arduino programlama dili hakkında daha fazla bilgi sahibi olmak, Arduino'yu etkili kullanabilmek ve arduino üzerinden projeler hazırlayabilmek.

[SC_PRE_OE-2]: My purpose for coming to the camp is to have information about Arduino Lilypad and to be able to do something about Arduino software and coding.

[SC_PRE_OE-2]: [Kampa gelmemin amacı] arduino Lilypad hakkında bilgi sahibi olmak, yazılım ve kodlama alanında birşeyler yapabilecek seviyeye gelmek.

The last motive that directs teachers to the camp was to learn new perspectives and to get familiarity with the STEAM fields. Seven of the teachers in the first camp and five of the second camp teachers indicated that they wanted to acquire new experiences, learn new ideas, and be aware of the latest studies using the STEAM integration.

[FC_PRE_OE-15]: I wanted to participate in this camp because it included STEAM wearable technology design topics.

[FC_PRE_OE-15]: Bu eğitime STEAM giyilebilir teknoloji tasarımı ile ilgili konular içerdiği için katılmak istedim.

[SC_PRE_OE-2]: I participated in this camp to learn stem-steam logic as an interdisciplinary learning-teaching method.

> *[SC_PRE_OE-2]: [Bu kampa katılmamın nedeni] disiplinler arası öğrenme-öğretme yöntemi olarak stem-steam mantığını öğrenmek.*

As reported above, teachers who attended the camp expected to learn various things that they believed would contribute to their professional development. At the end of each camp, teachers were asked to indicate how their expectations were met. The analysis of science teachers' responses to post-survey and open-ended questions revealed that the camp met most of the teachers' expectations successfully. As shown in Table 4.7, 96.8% of the teachers disagreed and strongly disagreed that the statement that "camp did not meet my expectations." Only one teacher reported being neutral about the camp's success in fulfilling the expectations. Likewise, many teachers (26% and 74% respectively) agreed and strongly agreed that they considerably benefitted from the camp in many aspects (see Table 4.6). One of the areas to which the camp made a significant contribution was perceived to be teachers' professional development. For example, all of the teachers agreed or strongly agreed that the camp contributed to the teaching profession's development (see Table 4.6).

Table 4.7 Enjoyment and satisfaction

Items	*M*	*SD*	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
The camp was generally useful.	6.77	0.50	-	-	-	-	3.23	16.13	80.65
I enjoyed doing activities in the camp.	6.65	0.61	-	-	-	-	6.45	22.58	70.97
The camp was boring for me.	1.19	0.40	80.65	19.35	-	-	-	-	-
I had fun during the camp.	6.77	0.50	-	-	-	-	3.23	16.13	80.65
I did the activities in the camp reluctantly.	1.10	0.30	90.32	9.68	-	-	-	-	-
I would not recommend this camp to my colleagues.	1.61	1.80	87.10	3.23	-	-	-	-	9.68
It was fun to do the activities in the camp.	6.58	0.76	-	-	-	3.23	6.45	19.35	70.97
The camp was well organized.	6.55	0.68	-	-	-	-	9.68	25.81	64.52
The camp did not meet my expectations.	1.29	0.64	77.42	19.35	-	3.23	-	-	-

On the other hand, eight of the teachers in the first camp and fifteen of the second camp teachers stated that what they experienced in the camp was literally in line with what they had previously expected to participate and gain.

[FC_POST_OE-8]: In this camp, I wanted to see how circuit elements and fashion design were combined. The camp met all my expectations.

[FC_POST_OE-8]: Bu kampta devre elemanları ile moda tasarımının nasıl birleştirildiğini görmek istemiştim. Tam anlamı ile beklentilerimi karşıladı.

[SC_POST_OE-2]: My expectation from the camp was to produce new ideas and contribute to my thoughts. The camp met all my expectations.

[SC_POST_OE-2]: Kamptan beklentim yeni fikirler üretmek, düşüncelerime katkı sağlamaktı. Etkinlik tüm beklentilerimi karşıladı.

[SC_POST_OE-17]: My expectations from the camp were to develop my occupational capabilities, to have some knowledge about STEAM activities to able to use in my classes, to be able to attract their attention more quickly by applying these activities in my classes. I think my expectations were met. I believe I can implement these activities now.

[SC_POST_OE-17]: Kamptan beklentim mesleki yeterlilik olarak beni geliştirmesi, derslerimde steam etkinliklerini kullanmak için bilgi sahibi olmak ve öğrencilerime [etkinlikleri] uygulayarak ilgilerini daha fazla çekebilmekti. Bu beklentilerimin karşılandığını düşünüyorum. [Bu etkinliklerin] uygulamasını yapabileceğime inanıyorum.

It seemed that some of the teachers' unfulfilled expectations stemmed from not being able to use more coding during the activities. For example, two teachers explained that the camp mostly met their expectations, but they were unsatisfied due to not learning much about Arduino coding. It seemed that those teachers anticipated involving in coding more than crafting, fashion, and design in the camp.

[SC_POST_OE-9]: I would prefer to spend more time on the coding part. The design part took most of my energy. Although I did not reach the goals such as code writing, I was able to satisfy my expectations by doing project designs using aesthetics, handcarft, and ready-made codes.

[SC_POST_OE-9]: Kodlama kısmı için daha fazla vakit harcamak isterdim. Tasarım kısmı benim enerjimi daha fazla aldı. Kod yazma gibi hedeflere ulaşmasam da estetik, el becerisi, hazır

kodlarla Lilypad projelerimizi hayata geçirmemiz beklentilerimi sonunda kadar sağladı.

[SC_POST_OE-15]: I learn to build a circuit that I have not learned through the years. I would expect myself to be more active in the coding part.

[SC_POST_OE-15]: Yıllardır öğrenemediğim devre kurmayı öğrendim. Kodlama kısmında daha fazla aktif olmayı beklerdim.

4.4.6.2 The positive characteristics of STEAM activities

Science teachers were probed to evaluate STEAM activities concerning the positive and negative aspects of the camp. The analysis of the responses to the group open-ended questions by a total of fourteen teachers from the first and second camp resulted in many positive characteristics teachers attributed to the STEAM activities. The same evidence was also reflected during the responses to open-ended questions by seven teachers from the first camp and twelve teachers from the second camp. Those characteristics ranged from good, productive, instructive, and useful to exceptional, entertaining, and intriguing. Teachers thought that these activities are informative and would make students' learning of electricity and circuits entertaining. In addition to that, the survey result showed that about 96.7% of teachers agreed or strongly agreed that they think the camp was generally useful (see Table 4.6).

[FC_GR_OE-4]: It meets the course objectives and concepts such as serial connection related to electricity. Thanks to these activities, the course can be taught in a funny and instructive way.

[FC_GR_OE-4]: Elektrik ile ilgili seri bağlama gibi kavram ve kazanımları karşılıyor. [Bu etkinlikler sayesinde] eğlenceli ve öğretici bir şekilde ders işlenebilir.

[SC_GR_OE-1]: The activities enable students to use hand skills and learn concepts related to circuits more funnily. It is both entertaining and instructive.

[SC_GR_OE-1]: Etkinlikler öğrencilerin el becerisini kullanmaları, devre ile ilgili kavramları daha eğlenceli bir

biçimde öğrenmelerini sağlar. Hem eğlendirici hem de öğretici bir etkinlik.

Two of the second camp teachers stated in the interviews that making a STEAM activity was so enjoying and amusing that they sometimes did not even be aware of how we handled the challenging parts of the design. Furthermore, teachers' responses to the survey questions evidenced the high degree of satisfaction and enjoyment in the camp. As shown in Table 4.7, 90.32 % of the teachers agreed or strongly agreed that it was fun and enjoyable to do STEAM activities in the camp. Likewise, 97% of the teachers agreed or strongly agreed that they had a lot of fun during the camp. Similarly, 23% and 70.6% of the science teachers, respectively, agreed and strongly agreed with the statement, "I liked doing STEAM activities in the camp."

Additionally, all teachers disagreed and strongly disagreed that "the camp was boring for me." Similarly, all teachers disagreed or strongly disagreed that they unwillingly made the camp's activities (see Table 4.7). Furthermore, the first and second camps' observations showed that many of the groups were utterly involved in designing their STEAM project and therefore forgot about a large amount of time passed.

[SC_INT-2]: Since the design part involves a very entertaining process, we even overcome the problematic stages in a fun way. We never questioned why we are doing this.

[SC_INT-2]: Tasarım süreci çok eğlenceli bir süreç olduğu için zor olan aşamalar bile eğlenceli bir şekilde atlatıldı. Hiç bunu niye yapıyoruz demedik.

Besides, as teachers described, STEAM activities were excellent and exceptional learning practices capable of invoking students' interests in learning electricity and circuits. A similar result was reflected in survey data, where all of the teachers (23% and 77% respectively) agreed and strongly agreed with the statement that "the camp has increased my interest and motivation in science, technology, engineering, art, and mathematics." (see Table 4.1).

[FC_GR_OE-3]: It was a beautiful and practical camp. In terms of designing a simple electrical circuit, the activities were

extraordinary and intriguing. I believe students' motivation would increase.

[FC_GR_OE-3]: Gayet güzel ve etkili bir etkinlikti. Basit elektrik devresi tasarlamak açısından gayet sıradışı ve merak uyandırıcı bir çalışma olur. Çocukların motivasyonu artacağına inanıyorum..

[FC_GR_OE-2]: The camp was very enjoyable. Great activities to teach parallel circuits.

[FC_GR_OE-2]: Kamp çok keyifliydi. Paralel bağlamayı öğretmek için harika uygulamalar.

It can be seen from the data in Table 4.7 that a vast number of teachers (28% and 65% respectively) agreed and strongly agreed that the camp had been organized well. Moreover, numerous teachers (96.7%) agreed or strongly agreed that they were willing to participate in similar future camps. For example, 94% of the respondents strongly agreed that three was a need to do the same or similar camps frequently in the future. The study results also showed that teachers were keen to attend similar camps again and recommend their colleagues to participate in the STEAM camp in the future (see Table 4.7).

4.4.6.3 Favorite parts of the activities

Science teachers were exposed to seven STEAM activities plus the final project in each of the camps. This part describes both the types and features of the STEAM activities the teacher mostly liked and enjoyed. Five of the teachers in the first camp and four of the second camp teachers reported in open-ended questions at the end of the camp that they liked all of the activities and enjoyed participating in them.

[FC_POST_OE-5]: I think all the activities were very nice. They all had a separate contribution to me. I even think that I have more to learn.

[FC_POST_OE-5]: Bence bütün etkinlikler çok güzeldi. Hepsi bana ayrı bilgiler kattı. Hatta daha fazla öğreneceklerim bile olduğunu düşünüyorum.

[FC_POST_OE-2]: I liked all the activities very much. We were able to experience different activities with the use of sensors. I also think that the activities support my professional development.

[FC_POST_OE-2]: Etkinliklerin tamamını çok beğendim. Sensörlerin kullanımı ile farklı etkinlikleri deneyimleyebildik. Ayrıca etkinliklerin mesleki gelişimimi desteklediğini düşünüyorum.

Two teachers from the first camp noted in open-ended questions that they mostly liked the parts involving coding the project and learning how to write a code for the design circuit.

[FC_POST_OE-1]: The activities were packed full in every area. I was more impressed with the parts where the coding was used.

[FC_POST_OE-1]: Etkinlikler her alanda dolu doluydu. Kodlamanın kullanıldığı kısımlar beni daha çok etkiledi.

The types of activities teachers enjoyed and had more fun while making were light-responsive lighthouse and color-changing scarf. The same view was reflected in open-ended questions. Two of the teachers in the first camp and four of the second camp teachers indicated that they had a good time while crafting a light-responsive lighthouse. As for the color-changing scarf activity, two of the first camp teachers and three of the second camp teachers stated that they were amused when designing the project where the scarf changed colors through a color sensor.

[FC_POST_OE-2]: We had so much fun while making the lighthouse. Creative ideas made us laugh a lot from time to time.

[FC_POST_OE-2]: Deniz fenerini yaparken çok eğlendik. Yaratıcı fikirler zaman zaman çok gülmemize neden oldu.

[SC_POST_OE-4]: The foulard activity we did with color-sensing sensors was a lot of fun.

[SC_POST_OE-4]: Renk algılayan sensörler ile yaptığımız fular etkinliği çok eğlenceliydi.

Also, two of the teachers in the first camp and four of the second camp teachers stated in open-ended questions that the group project they designed at the end of the camp was relatively more enjoyable than the other parts of the camp.

[FC_POST_OE-3]: I enjoyed the design product that was emerged after the project was completed. The process was painful, especially the sewing part.

[FC_POST_OE-3]: Projelerin tamamlaması sonucunda ürünü ortaya çıkardığımızda çok keyif aldım. Süreç zahmetliydi özellikle de dikiş kısmı.

[SC_POST_OE-5]: My favorite activity in the STEAM camp was the last session where we made our group project design.

[SC_POST_OE-5]: MODAK kampında en beğendiğim etkinlik son etkinlik olarak bir tasarım yaptığımız bölümdü.

4.5 Challenges associated with designing and implementing STEAM activities

This theme describes the findings on problems, issues, and challenges associated with STEAM activities. It is split into four parts: the application of STEAM activities in the school and the implementation of STEAM activities in the camp. The first part covers the problems, issues, and challenges that are believed to occur when the STEAM activities are applied in the school. In contrast, the second part presents the problems, issues, and challenges regarding the art-focused activities in the STEAM training camp.

4.5.1.1 Implementation of activities in school

Science teachers pointed out a wide variety of problems in applying STEAM activities in the school environment. The inadequate or inappropriate school environment turned out to be one of the significant obstacles to implementing STEAM activities in public schools. Four of the first camp teachers, who were teachers in the public school, indicated in the interviews that the majority of the public schools either lack a suitable space or the design of the current physical classroom space is not appropriate for applying such interdisciplinary activities. Therefore, they worried that an inappropriate school environment would undoubtedly interfere with STEAM activities' implementation in schools. These results point to a great need for a classroom or laboratory environment specifically designed to fulfill the conditions demanded by hands-on activities.

> *[FC_INT-3]: Not because that I have access to materials, but the lack of suitable classes, working place, laboratories, and materials and, in short, not having a specific order will make it challenging to implement the activities.*

> *[FC_INT-3]: Malzemelere ulaşabildiğimden değil de sınıfların, atölyenin, labaratuvarın kısacası belirli bir düzenin olmayışı etkinliklerin uygulanmasını zorlaştıracaktır.*

> *[FC_INT-5]: There are activities that I have applied in my classes occasionally. There are two significant problems, especially in public schools: budget and design-oriented classroom. We are still lecturing in a traditional classroom, and for the group work, we generally combine classroom desks.*

> *[FC_INT-5]: Şimdi daha önceden derslerimde zaman zaman uyguladığım etkinlikler var. Özellikle devlet okullarında iki büyük problem var: bütçe ve tasarıma uygun sınıflar. Biz hala geleneksel sınıflarda ders anlatıyoruz ve grup çalışması için genellikle sıraları birleştiriyoruz.*

Insufficient in-school time was described to be another challenge in the application of STEAM activities in schools. Three of the teachers interviewed in the first camp complained that the scheduled course time would not be suitable to teach the theoretical science concepts and implement STEAM activities simultaneously. As teachers underlined, the amount of course time in schools allowed them to teach only the science concepts and not apply e-textile activities. However, teachers thought that they, as a compensating strategy, could use a certain amount of time from elective courses instead of stealing time from the main course.

> *[FC_INT-1]: However, we may only select a few of these activities due to time constraints. We cannot implement all of them within the class hour because we need to draw the circuit diagram in the electrical unit, which takes a lot of time. So, it can be used as content, but a maximum of three activities can be applied. Of course, I consider the relationship between the lesson objective and time.*

[FC_INT-1]: Ancak süreden kaynaklı olarak bu etkinliklerden birkaç tanesini seçebiliriz. Hepsini, ders süreci içerisinde kullanamayız. Çünkü elektrik ünitesi içinde, devre şeması çizmemiz gerekiyor ve bu çok vakit alıyor. Bu yüzden içerik olarak kullanılabilir, ama maksimum üç tanesi kullanılabilir. Kazanım ve süre ilişkisini göz önüne alıyorum tabiki.

[FC_INT-4]: I certainly will apply. I may not be able to do it in my class, the main science course, but if I take an elective course, such as the science applications course, I will apply it there because I have to teach the main course subject in the main science course. Also, I cannot find materials to do an activity with students. After putting instructions in front of students and grouping them, I can do these kinds of activities. Students work on their projects every week. If I do this, students will be much more successful. But while teaching the main course, it is tough to teach the subject and simultaneously do such activity.

[FC_INT-4]: Kesinlikle yapacağım. Dersimde yani ana derste yapamayabilirim, ama bilim uygulamaları gibi seçmeli bir ders alırsam orda uygularim çünkü an derste ders anlatmak zorunda kalıyoruz. Ayrıca çocuklarla etkinlik yapmak için malzeme bulamıyorum. Aslında çocukların önlerine yönergeler koyup onları grup yaptıktan sonra, bu tarz çalışmaları yapabilirim. Her hafta kaldıkları yerden devam ederler. Bunları yaparsam çok daha başarılı olurlar. Ama ana dersi öğretirken, hem konuyu anlatıp hem de böyle bir etkinlik yapmak inanın çok zorlar.

Besides, three of the first camp teachers expressed in the interviews that the times specified for STEAM activities would not be adequate for students. The observations from both camps showed that groups of teachers gave most of their activity time to sewing and crafting and, therefore, some groups failed to complete their project design within the specified time. As a result, due to their undeveloped sewing and handcrafting skills, it would take even a longer time for students to complete a STEAM project design.

[FC_INT-1]: The activities require a bit more effort and time, especially when combined with design and crafting. If we want to conduct these activities with students, we need a longer course time and process.

[FC_INT-1]: Etkinlikler özellikle tasarım ile birlikte yapıldığında birazcık daha emek ve zaman istiyor. Çocuklara bu etkinlikleri

yapmak istediğimizde bu kadar kısa zamanda değil de daha uzun bir zaman ve süreç isteyen bir durum gerekir.

[FC_INT-5]: Design work took my time. Apart from the design, the circuit was easy to construct and complete. The aesthetic and decoration work that followed the project design didn't take much of my time. This will take students' time as well. I am sure that students will have nice ideas related to the design.

[FC_INT-5]: Tasarım çalışmaları benim zamanımı aldı. Tasarım dışında devreyi kurmak ve tamamlamak kolaydı. Bundan sonrası dekorasyon ve görselliğe baktığı için o benim zamanımı almadı. Bu öğrencilerin zamanını da alacak. Tasarım ile ilgili öğrencilerin de kafasında çok güzel fikirler olacaktır eminim.

It was noted that crafting STEAM activities depended to a great extent on the use of fine muscles, and students compared to teachers, were deprived of adequate sewing and handcrafting skills. Two of the first camp teachers stated in the interviews that there was a high possibility that students would experience difficulties in sewing and stitching their STEAM project. However, they added that this challenge would not remain the same throughout all the STEAM activities. Students' initial practices with STEAM activities at the earlier stages will go with experiencing trials and errors and asking for assistance, which, in turn, help them sew by themselves.

[FC_INT-5]: Students could struggle with sewing at first, just like we did at the beginning of the camp. I am not the type of person who sews, but sewing became comfortable for me after pricking my hand with the sewing needle a few times. If we have reached this stage at the end of the 4th day, students will also improve hand and crafting skills if they collaboratively implement STEAM activities in the technology design course. Small muscle development is very important for students. We are no longer at the information level, so we need to use the skill. Students need to have talent. Since students will be performing the activities for the first time, they may have problems in terms of time. To overcome this, maybe two hours of practice per week can be done with in-class or extracurricular activities. The activities can be implemented in an elective course, a science applications course. Students can do practices about activities at home, but I don't think they will suffer much in general. It may be easy for female students, but male students may find it much more difficult.

[FC_INT-5]: Öğrenciler el becerileri yüzünden ilk etapta zorlanabilir ki biz de zorlandık. Ben dikiş diken birisi değilim. Fakat, birkaç kere iğneyi elime batırdıktan sonra rahat oldu. 4. günün sonunda bu aşamaya geldiysek, öğrencilerin de teknoloji tasarım dersinde iş birliği yaparak STEAM etkinlikleri yaparlarsa el becerileri gelişecektir. Küçük kas gelişimi çok önemli çocuklar için. Biz artık bilgi basamağından değil, beceriyi kullanmamız gerekiyor. Çocukların beceri sahibi olması gerekiyor. Bu çok önemli. Çocuklar etkinlikleri ilk defa yapacaklari için ilk etapta belki süre açısından uygularken sorun yaşayabilirler. Bunun üstesinden gelnek için belki ders içi veya ders dışı etkinlikle haftada iki saatliklik bir uygulama yapılabilir ya da bilim uygulamaları dersiyle kapatılabilir. Çocuklar evde kendileri biraz pratik yapabilirler ama genel olarak çok da sıkıntı çekeceklerini düşünmüyorum. Kız öğrenciler için belki kolay olabilir fakat erkek öğrenciler çok daha zorlanabilir.

[FC_INT-1]: I have some doubts about whether the students can sew because even the teachers had difficulty doing it. For example, on the first day, we all struggled to sew, and then we all got used to it, but students could harm themselves. These activities can be used in accordance with the class level.

[FC_INT-1]: Çocukların hepsi dikiş yapabilir mi orada biraz şüphelerim var çünkü öğretmenler bile yaparken zorlandılar. Mesela ilk gün hepimiz zorlandık, sonradan hepimiz alıştık ama çocuklar kendilerine zarar verebilir. Sınıf seviyesine uygun olarak kullanılabilir bu etkinlikler.

Two of the teachers, who were rural school teachers, in the second camp expressed in the interviews that students' exam-oriented performance goals and parents' lack of awareness of the importance of STEAM activities could be a barrier to applying STEAM activities in rural schools. The teacher explained that parents might not want their children to spend their time doing these activities. Because most of the parents are outcome-oriented and tend to reward exam performance over performance-experiences acquired during the STEAM activities. In Turkey's context, there could be a significant variation among public schools depending on their location. Rural schools are likely to be inferior to urban schools in terms of the intellectual level and awareness of school students' parents.

[SC_INT-1]: I am thinking about the district where I teach. The students there do not care about the school and also do not have

high expectations. This is mainly due to the parents. Parents come to school and merely talk about how their children could succeed in high school or university entrance exams. Since the students are always opted to focus on the exams, I continuously strive to discourage them from this attitude.

[SC_INT-1]: Ben çalıştığım bölge itibariyle düşünüyorum. Ordaki çocukların okulla alakalı ve çok fazla beklentileri yok. Bu çoğunlukla veliden kaynaklı oluyor. Veli gelip sadece öğrencinin lise veya üniversite kazanması üzerine konuşuyor. Öğrenciler sürekli sınav odaklı çalıştıkları için ben bunu sürekli bozmaya çalışıyorum.

[SC_INT-3]: Of course, I see that such activities can be done more easily in central schools, especially those located at the center of provinces, as they have more opportunities and the parents who live in there are a bit more conscious of these activities. Schools in urbanized areas encourage their students or financially support them. That is why better projects take place in such schools. But I am in a small region, a village school. Our conditions, therefore, are not good. In this regard, lots of works and efforts have to be made to spread these activities around. We need to raise our voice a bit more.

[SC_INT-3]: Tabi bu tarz etkinliklerin merkez okullarda daha kolay şekilde yapılabildiğini görüyorum, özellikle de il merkezlerindeki okullarda. Çünkü oradaki olanaklar biraz daha fazla ve veli bu konuda biraz daha bilinçli. İllerdeki okullar öğrencisini destekliyor ya da onda maddi anlamda destek oluyor. Bu anlamda okullarla birlikte çok güzel projeler ortaya çıkıyor. Ama ben bir ilçedeyim, köy okulundayım. Şartlarımız ona göre müsait olmuyor. O yüzden bu etkinliklerin etrafa yayılması açısından çalışmaların biraz daha artması gerekiyor. Biraz daha sesi arttırmamız gerekiyor.

The STEAM activities are designed through the problem-based structured format in which groups of teachers or students create their projects using the available e-textile materials. Each activity form composes of several parts. One of them, a circuit diagram, represents how sewable electronics are connected in the circuit. One of the first camp teachers stated that giving a ready circuit diagram might lead students to memorize the subject. However, both camps' observations showed that despite the given activity circuit diagram, most of the groups kept having difficulties in stitching a working circuit such as short circuit, wrong connection, etc. Therefore, it might be useful to decide whether to attach a circuit diagram based on the students' needs.

> *[FC_INT-4]: I could comprehend it, and I think students can do it too. I wondered if we forced students towards memorization-based learning. I hung it up for a while and tested whether I could do it myself without the circuit diagram. We were very committed to the booklet, and I thought it was memorization-based. I was wondering if we drove students to memorization. At first, we can hand the circuit diagram to the students to check out and then take it back from those who willingly looked at it. Because then they would do it by merely looking at the diagram. In this case, learning will not take place, and the only memorization will happen. We looked at the design and thought about what we put and where. I asked myself, did I like a person who does rote learning? At home, I said that "I will let myself make the circuit while designing the necklace," and I lit the LED, which made me feel that at least I am learning this way. You can tell the students how you sew from positive to negative tab. You can draw a simple series circuit on the board or just let the students find the circuit diagram themselves. You first ask them to construct the circuit and then transform it into the design once you see their circuit functions.*

> *[FC_INT-4]: Ben algılayabiliyorum, çocuklar da bence algılayabilir. Acaba çok fazla mi ezbere dayalı gidiyoruz diye düşündüm. Bir ara kapattım ve kendimce devre semasi olmadan yapabiliyor muyum, onu test ettim. Kitapçığa çok bağlı kaldık, bunun ezber odaklı olduğunu düşündüm. Acaba çocukları da ezbere mi götürürüz diye düşündüm. İlk başta [öğrencilerin]ellerine [devre şeması] verip bakmaları sağlanabilir, kim isteyerek düzgün bakıp dinlediyse sonra ellerinden toplamak olabilir. Çünkü sonra baka baka yapacaklar, öğrenme gerçekleşmeyecek ve ezber olacak. Bizde şöyle bir bakıyoruz neyi nereye koysak. Ezberci gibi mi oluyorum, dedim kendi kendime. Evde dedim "ya kolyeyi yaparken bırakıyım ben kendi kendime devreyi kurayım" ve yaktım dedim, en azından öğrendiğimi hissettim bu şekilde. Çocuklara şunu da söyleyebilirsin, burada artıdan eksiye seri bağladın. Tahtaya basit bir seri bağlama çizin ya da devreyi kendilerinin de bulmasını isteyebilirim. İlk önce devreyi kurdurmalarını isteyip, devrenin yandığını gördükten sonra da tasarıma dönüştürebilirler.*

Schools might not afford to buy activity materials, specifically wearable e-textile technologies, which are relatively more expensive than the other crafting materials and tools. That's why any attempt to implement activities in schools is doomed to failure. Five of the teachers in the first camp and one of the second camp teachers expressed in the interviews that implementation of STEAM activities in schools depended upon the schools' affordability and accessibility to activity materials. Teachers explained that public schools, especially in rural areas, suffered from limited budgets and could not afford to fund essential materials and tools needed for the STEAM activities. Furthermore, all the teachers thought that they had the ability and willingness to apply STEAM activities in their schools. Still, it did not seem to be possible without access to the e-textile materials.

> *[FC_INT-1]: It is difficult to find the appropriate materials for the selected activities, especially for the schools located in rural areas and suffer from a low financial budget. Right now, even a teacher has to pay 100-200 ₺ to buy a Lilypad and work with it. But considering the current situation, this may not be possible. If you consider the number of students in these schools, which is very high, it is impossible to give each child Arduino Lilypad. For example, you cannot use a single Lilypad for 120 students in 7th grade.*

> *[FC_INT-1]: Seçilen konulara uygun materyallerin bulunması çok zor, özellikle kırsal kesimlerde olan ve maddi durumu dar olan okullarda bunların uygulanmasının zor olduğunu düşünüyorum. Bir öğretmen bile bir Lilypad ile çalışma yapabilmesi için 100-200 lirayı gözden çıkarmak zorunda. Fakat şu andaki durumu düşününce bu pek mümkün olmayabilir. Ayrıca bu okullardaki öğrenci sayısını düşünecek olursanız ki baya fazla, her çocuğa Lilypad vermeniz mumkun degil. Örneğin 7. sınıflarda 120 öğrenci için tek bir Lilypad kullanamazsınız.*

> *[FC_INT-2]: I am eager and looking forwards to implement these activities. I can implement these activities, but we have a financial budget issue at the public schools, as I said. I am supposed to obtain these activity sets first, and then I can implement them. But, you can not make the first one without having sufficient money.*

> *[FC_INT-2]: Etkinlikleri uygulamak için hevesliyim ve fırsat kolluyorum. Bu etkinlikleri uygulayabilirim, ama bunun için dediğim gibi devlet okulunda finansal bütçe durumumuz var bizim. Öncesinde bu setleri alıyor olmam gerekir, sonrasında de devreye sokmak gerekir. Fakat para olmadan ilkini yapamıyorsunuz.*

Design principles for the implementation of STEAM activities in school settings

If a STEAM camp was to be conducted in a school, it is not advised to do it in the classroom; because the majority of the classes in public schools do not have adequate physical space and appropriate arrangement for the STEAM-like hands-on activities. The physical classroom environment could be rearranged to allow several groups of students to conduct the activities. If there is no suitable environment, then the camp could be made in the classroom with fewer students.

The amount of time used in the camp for each STEAM activity was determined based on what science teachers could achieve. But when it comes to the students, more time should be allocated for each activity because students may not be able to complete their project design within the allotted time due to their undeveloped psychomotor skills. Furthermore, at least ten minutes break between activities should be given to the students so that they could rest both physically and mentally before starting to conduct the next activity.

Middle school students' fine muscles and coordination skills, especially those in 5th and 6th-grade levels, may not be matured enough to fully control the needle and sew STEAM projects with a conductive thread. Therefore, students should be introduced to sewing in advance of the camp. Sewing practices could be done in a session where the teacher teaches or trains students to sew an LED into 2mm felt fabric with conductive thread.

Some of the students' parents might be outcome-oriented and interested in sending their children to activities that focus only on increasing test scores. In such cases, the parents must know what their children will get involved in and accomplish during the camp. For doing that, parents' consent must be taken first. To do that, they should be informed about the camp activities and their potential contributions to students' knowledge and skills in various subjects.

The location of the school could interfere with the ways the camp is implemented. It seems that schools that are located in urban areas are likely to be more advantageous than others in rural areas in the possibility of implementing the camp. The opportunities and facilities available for a camp in an urban school might not be present in a rural school. On the other hand, there could be differences between urban and rural students regarding knowledge levels, interests, mindsets, etc. All these together should be considered while either preparing the content of the STEAM activities or planning to implement the camp.

The circuit diagram is one of the critical elements of every STEAM activity. Without the circuit diagram presence, students most probably would not be able to make the right connections between circuit components in their project design. Therefore, the circuit diagram representing how sewable electronics are connected in the project circuit should be given to the students along with other activity documents.

The schools' affordability and accessibility to the camp materials are crucial. However, most public schools, especially those in rural and undeveloped districts, cannot afford to buy the camp tools and materials, particularly wearable e-textile technologies, which are expensive compared to the other textile and crafting materials that are used in the camp. The schools or teachers who are planning to organize a STEAM camp should set their budget first and tally all of the resources in hand, considering the materials necessary to be available at the camp.

4.5.1.2 Implementation of activities in camp

Science teachers reported many challenges in a wide variety of areas related to implementing STEAM activities in the camps. The areas of challenges teachers focused on ranged from art, circuit, collaborative teamwork, design sketch, forming a design solution, and materials and tools to sewing and handcraft and timing and effort.

Coding circuits with the Lilypad Arduino

In the first and second camp, the workable circuit codes, which were prepared in advance for each activity with Arduino Lilypad, were provided to the group of teachers once they completed designing their project. Therefore, they did not need to write any code at all. However, they were allowed to change a piece of code to observe its effects on the circuit. The analysis of the teachers' responses to open-ended questions at the end of each camp showed that teachers had problems in Arduino coding. Specifically, four of the teachers in the first camp and three of the second camp teachers stated that it was challenging to code circuits with the Lilypad Arduino. A similar situation was observed in both camps. The groups whose members did not have previous Arduino programming language experiences and familiarity with the Arduino development environment had more difficulties in Arduino coding.

> *[FC_PO_OE-1]: I would say that I had difficulty time in coding. This could be due to the fact that I had not have any knowledge about the subject before.*
>
> *[FC_PO_OE-1]: Kodlama noktasında zorlandığımı söyleyebilirim. Daha önce konu eğitim ile ilgili bir bilgimin olmamasi buna etken olabilir.*
>
> *[SC_PO_OE-15]: I struggled with the initial coding part. Because I didn't have any background knowledge about it. But, following the instructions provided made me suffer less in the following activities.*
>
> *[SC_PO_OE-15]: İlk baştaki kodlama kısmında zorlandım. Çünkü herhangi bir altyapim yoktu. Fakat, verilen bilgiler doğrultusunda ilerleyen etkinliklerde sıkıntı çekmedim.*

Art

One of the teachers in both the first and second camps expressed in the interviews that it was quite challenging to craft a project design with great artistic merits and values. The observations also showed that teachers as a group had put a lot of effort into making their designs aesthetically good looking and functionally well working. Analysis of teachers' responses to group open-ended questions revealed some of the struggling efforts teachers went through to add art to their project design. Specifically, five of the teachers in the first camp and three of the teachers in the second camp stated that the areas that they struggled with during the project design process included color selection, felt and fabric cutting, embellishing, gluing, sewing, and soldering.

Additionally, one teacher emphasized that they, as teachers, inclined to focus more on functional aspects over the aesthetic aspect of the design. What the teachers emphasized above were observed many times in the camps. Most of the teachers, as groups, as soon as they got the activity materials and cut a piece of felt or fabric, they immediately started to sew wearable e-textile technologies to that felt or fabric without any contingency plan or strategies about the crafting works they were going to apply. Maybe teachers have a common tendency to bypass or underestimate the merit of art-related work in the project design, or they may simly lack artistic abilities.

> *[FC_INT-2]: People want to create first a product, to light the LED second, and then to reflect on the design part, which is actually not a correct method. I am trying to explain that product and design should be twisted. I have always had this problem with a friend. My groupmate was a bit impatient and therefore started to design immediately. I said to him "stop and let's first draw the design because the project may fail or things may not go well". Project itself and design both have to go hand in hand.*

> *[FC_INT-2]: İnsanlar ilk once bir ürün çıksın, led yansın daha sonra tasarım diyorlar ama aslında bu böyle değil. Ürün ve tasarımın beraber olması gerektiğini anlatmaya çalışıyorum. Arkadaşla hep bu problemi yaşadım. Grup arkadaşım biraz tez canlı olduğu için hemen tasarıma başlıyordu. Dur diyorum biz çizelim belki olmayacak ters olacak falan. İkisinin aynı anda gitmesi gerekiyor.*

> *[SC_INT-4]: The design part was the most challenging part. This, in fact, showed us how we lacked necessary skills. It is easy to do a STEAM activity, but when design and art are involved, it necessitates owning some sort of skills which everybody may not possess. I think that art was the most challenging part of the activity.*

[SC_INT-4]: Tasarım kısmı bizi en çok zorlayan kısımdı. Bu da bizim aslında eksikliğimizi gösteriyor. STEAM etkinliği yapmak biraz kolay, ama işin içine tasarım ve sanat girdiği zaman biraz yetenek işi gerektiriyor. O da herkeste yok. Bence bizi en çok zorlayan etkinlik kısmı sanattı.

Camp space

Both camps were carried out in a large hall with almost no windows, but there was air conditioning in the room, which was big enough to let some fresh air into the camp environment. However, one of the teachers in both the first and second camps stated in open-ended questions that the camp space was airless. The number of people in the camp environment, which was generally over thirty, could be one of the reasons why teachers felt that there was not enough fresh air.

[SC_POST_OE-15]: Overall, we did not have any problems. It was just a little stuffy.

[SC_POST_OE-15]: Genel olarak herhangi bir problem yoktu. Sadece ortam biraz havasızdı.

However, the analysis of teachers' responses to survey questions demonstrated that almost all of the teachers were content with the conditions in the camp hall and the facilities that were provided during the four-day camp (see Table 4.8). For example, compared to 29% of the teachers who agreed or strongly agreed with the statement, "the camp environment was airless," 45.2% disagreed or strongly disagreed that the camp environment did not have adequate fresh or moving air. Also, a great majority of teachers (16% and 68% respectively) agreed and strongly agreed that the building where the STEAM activities were implemented had adequate technological facilities. Related to the easy of transport to the camp place, 67.7% of the teachers did not agree or strongly agreed that getting to the camp place was difficult. In addition to that, teachers were also asked to demonstrate how much they were satisfied with the quantity and quality of the food provided to them during the four-day camp. The survey responses showed that except one teacher who disagreed, 16.1% and 72.2% of the teachers, respectively, agreed and strongly agreed that the food was plentiful and tasty.

Table 4.8 The camp setting

Items	*M*	*SD*	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
The technological infrastructure at the campsite was adequate.	6.52	0.77	-	-	-	-	16.13	16.13	67.74
The place where the activities took place was stuffy.	3.55	2.35	32.26	12.90	6.45	9.68	9.68	12.90	16.13
The food provided in the camp was plentiful and delicious.	6.55	1.03	-	3.23	-	-	6.45	16.13	74.19
Transportation to the campsite was difficult.	2.45	1.84	45.16	22.58	6.45	6.45	9.68	6.45	3.23

Design circuit

E-textile circuit design is a crucial and integral part of STEAM activities. Each STEAM activity requires the construction of a particular e-textile circuit, which is a group of wearables electronics sewed together by a conductive thread. Teachers reported some problems related to the design circuit. Specifically, two of the teachers in both the first and second camps expressed in the interviews that they grappled with several circuit-related issues. The similar problems were reported in teachers' responses to the group's open-ended questions. Four of the teachers in the first camp and six of the teachers in the second camp stated in the group open-ended questions that the design circuits they sewed did not work correctly due to some circuit-related problems. The most common areas where teachers confronted with these issues were about the current flow (short circuit), connections (series and parallel circuit), and polarity.

> *[FC_INT-1]: The circuit diagram was not too much confusing to me. As I said, I had trouble with short circuit because I had to sew the circuits from the back. I've made some fine work on the project design… At the same time, for example, when students are sewing those circuits with the conductive thread, the strands or traces of thread could touch. You may not have the same degree of success on sewing in every child.*
>
> *[FC_INT-1]: Devre şeması çok karışık gelmedi. Dediğim gibi sadece dikerken devreleri arkadan dikmem gerektiği için kısa devre konusunda sıkıntı yaşadım. Tasarım üzerinde ince işçilik yaptım…Aynı zamanda, mesela çocuklar o devreleri dikerken elektrik ipleri birbirine değecek şekilde dikebilirler. Her çocukta aynı derecede başarı elde edemeyebilirsiniz.*
>
> *[SC_INT-3]: In the circuit components that we use, since we solder thin wire, even the slightest disconnectedness can affect the whole circuit. Soldering part was difficult for me. In fact, I think that I will continue to practice in these areas in order to improve my level of expertise.*
>
> *[SC_INT-3]: Kullandığımız devre elemanlarında, lehimleme de çok ince yaptığımız için en ufak bir temassızlık bile bütün devreyi etkileyebiliyor. Oralarda biraz zorandım. Aslında bu alanlarda sürekli pratik yaparak daha ileri seviyeye gideceğimi düşünüyorum ben.*

Besides, observations from both camps showed that almost all of the groups had to deal with the problems about short circuits and series and parallel circuits. These findings suggest that when it comes to putting the theoretical knowledge of circuitry into practice, even science teachers could have challenging experiences in sewing a working circuit. The similar and even more problems would probably be experienced by students when they engage in STEAM activities. Experiencing such kinds of circuit-related problems could be advantageous for both teachers and students to learn from DIY experiences.

[FC_GR_OE-3]: We experienced a short circuit due to the touching of conductive threads and connection problems with the coin battery holder.

[FC_GR_OE-3]: İletken kabloların birbirine teması sonucu kısa devre ve pil yatagi ile temassızlık problemleri yasandık.

[SC_GR_OE-5]: We could not prevent the traces of conductive thread to touch each other in parallel and series circuit, and therefore a short circuit took place.

[SC_GR_OE-5]: Paralel ve seri baglamada iplerin temasını engelleyemedik ve bu yüzden kısa devre oldu.

Collaborative teamwork

Although teachers from both camps did not report any difficulties related to the collaborative work, the observations showed that that at least one or two groups in both the first or second camp did not have efficient teamwork as it would generally be. More specifically, in those groups, for example, one of the group members just sat down and almost did nothing throughout the activity. On the other hand, the other group member did all the work necessary for the project design. This situation was not common throughout the camp, but there were several occasions that some group members did not work in harmony. For the STEAM activities, however, collaborative teamwork is crucially essential and even could be a reliable indicator of the project design. Because it is likely that the more active the groups work collaboratively, the better design they would produce.

Design sketch

In both camps, groups of science teachers designed their STEAM projects following the design thinking phases. The third phase of design thinking is the design sketch, which is a simple visualization and rough drawing of the e-textile project design plan. The design sketch shows in detail the types of materials to be used and their relative positions along with the placement of circuit components. In the camps, groups were instructed to sketch their project design on a design sketch form provided to them in the camp activity booklet. This phase is rather vital because whatever decisions teachers made at this phase would then inform the overall design process. Four of the teachers in the first camp and five of the teachers in the second camp stated in the group open-ended questions that they experienced many difficulties in making the transition from sketch to project design. Consequently, it seemed to be challenging for groups to successfully put their design into sketch or what they were thinking into action during the design process.

> *[FC_GR_OE-5]: In our design, we had difficulty in sewing the materials as we planned at the beginning.*
>
> *[FC_GR_OE-5]: Yaptığımız tasarımda planladığımız gibi malzemeleri birleştirmede zorlandik.*
>
> *[FC_GR_OE-6]: We, as a group, often had difficulty in transferring the draft to the design.*
>
> *[FC_GR_OE-6]: Biz grup olarak genellikle taslağı tasarıma aktarırken zorlandık.*
>
> *[SC_GR_OE-5]: We tried to make our design three-dimensional. That is why we had a hard time putting it together. The sewing and joining part are not as easy as in the design plan. It was difficult to shape because we used thick felt when transferring our plan to the design.*
>
> *[SC_GR_OE-5]: Tasarımızı üç boyutlu yapmaya çalıştık. Bu yüzden de bir araya getirmekte zorlandık. Dikme ve birleştirme kısmı tasarım planındaki gibi kolay gerçekleşmiyor. Planımızı tasarıma aktarırken kalın keçe kullandığımız için şekil vermek zor oldu.*

The following image, for example, illustrates the avulution of a project design, from sketch to the final product (see figure 4.3). As clearly seen in the figure, there are huge differences between what has been drawn and what has been produced. It should be also noted that for the simple projects like this one the desing sketch might have some missing drawings, but when it comes to the complex project, one missing drawing could have a huge impact on the final design.

Figure 4.3. A necklace project from sketch to the final design

For teachers, drawing an elaborative design sketch was another challenging part. Teachers in their responses to open-ended questions explained that even though they strived to reflect all their plans in the design sketch, they could not achieve to come up with an elaborative one. The same view was evidenced in the design sketches that they had drawn for the activities. That is, when analyzing the design sketches that were drawn by teachers in both camps, it was observed that almost all of the design sketches were missing, even the basic schematic drawings. For example, figure 4.4 below illustrates two design sketches drawn by different groups for the same activity which was about designing a color-changing star cluster. However, the design sketches barely looked like the star cluster and lacked essential details about the design to be crafted. For example, two design sketches lacked information about the types of materials to be used and where those materials would be placed and stitched.

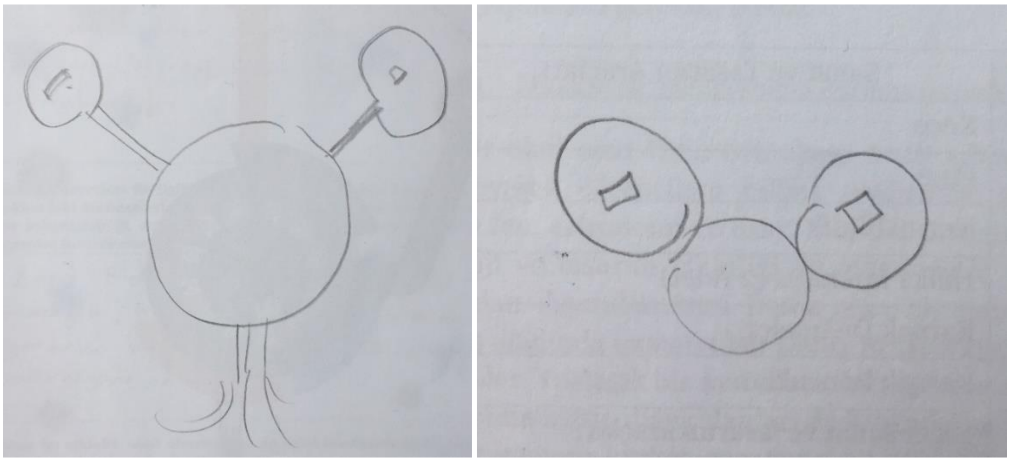

Figure 4.4. Design sketch for the star cluster activity

Observations from both camps and the design sketches demonstrated that most of the groups did not consider their design sketch while crafting a project prototype. In addition to that, the majority of the groups completely arbitrary sketched their design plan because they were so vague that it was even hard to call them a sketch. Ignoring the design sketch and lacking an elaborative design sketch could be the main reason why groups encountered so many problems during the project design.

Teachers were supposed to follow design thinking stages so that they could avoid the occurrence of such problems. For instance, one of the teachers in the first camp expressed in the interviews that the issues they had during the design process were generally due to the reason that they diverged from the design thinking stages. The third stage was about the design sketch. It described how the design sketch should be drawn and what elements should be mainly considered while drawing a design sketch. It seemed that most of the groups did not give attention to what was written in the design sketch and used their eclectic methods to draw an outline.

> *[FC_INT-5]: The problems we faced were usually due to our failure to follow the design cycle. When we do not do the design well, we encounter a problem.*
>
> *[FC_INT-5]: Karşılaştığımız problemler genellikle bizim döngüyü çok iyi takip etmememizden kaynaklaniyordu. Tasarımı iyi yapamadığımız zaman bir şekilde bir problemle karşılaşıyoruz.*

On the other hand, there are relatively few design sketches that were partly better than the others but still deprived of the details about the design to be crafted. One of them was shown in the figure below. As seen in Figure 4.5, the sketch included details about the front and backside of the project design. There was also information about the e-textile materials to be used and their relative positions. However, the sketch lacked information about the types, colors, and sizes of the crafting materials to be used. An ideal design sketch should at least present a circuit design blueprint along with the crafting materials mapped onto the design.

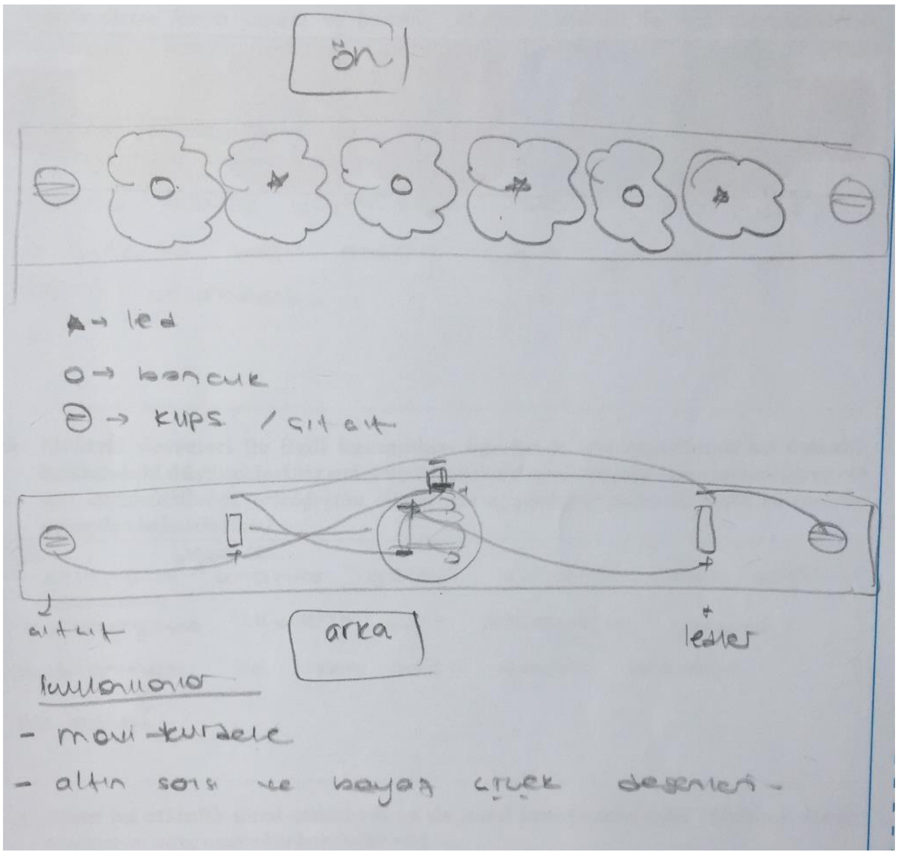

Figure 4.5. Science teachers’ opinions and experiences on STEAM activities

Forming a unique design solution

The STEAM activities were problem-based interdisciplinary activities. In both camps, groups of science teachers generated and crafted designs as solutions to the problem situations posed in STEAM activities. However, the result showed that forming a unique design solution turned into a challenging process for some of the teachers. For example, two of the teachers in both the first and second camps stated in the group open-ended questions that they had difficult times to come up with a sensible design structure. This problem was observed in several groups during the camps. Groups stuck with thinking about the type of project design they should go with when it came to finding a functional and aesthetic design. Another problem observed during the camp that groups' overthinking about the design somehow drove them to neglect the relation of design with the used e-textile technologies. As a result of this, an apparent mismatch occurred between the design solution they proposed and the types of e-textile technologies they used. For example, if a traffic light is to be designed with e-textile technologies, it is important to use red, yellow, and green LED, and also sew them in this order from top to bottom so that the design resembles the traffic light in real life.

> *[FC_GR_OE-2]: We struggled to decide on the type of the design.*
>
> *[FC_GR_OE-2]: Tasarıma karar vermekte zorlandık.*
>
> *[FC_GR_OE-7]: The stage of making a decision on what design we were going to create was harder than the other stages.*
>
> *[FC_GR_OE-7]: Ne tür bir tasarım yapacağımıza karar vermek diğer aşamalardan daha çok zor geldi.*
>
> *[SC_GR_OE-1]: Frankly, I had a hard time while producing new designs. I never had to think like that before when I was designing and producing content.*
>
> *[SC_GR_OE-1]: Açıkçası yeni tasarımlar üretmede cok zorlandım. İçerik üretirken ve tasarım yaparken daha önce hiç düşünmek zorunda kalmamıştım.*

Materials and tools

In both camps, e-textile technologies and crafting materials were used to make a STEAM design. While working on their design, teachers experienced a bunch of failures and problems related to the materials and tools they used. The failures and problems related to the camp materials are divided into three parts: durability, quantity, and unfamiliarity. As for the durability of materials, three of the teachers in both the first and second camp stated in the group open-ended questions that the some of the e-textile technologies, particularly Lilypad, was broken or didn't work properly during the activities. Two of the teachers interviewed in the first camp mentioned the same problems.

> *[FC_INT-5]: One of the sewable electronics turned out to be broken. Then we replaced the broken one. Other than that, I can not say that we had a big problem. Overall, we finished all the activities.*
>
> *[FC_INT-5]: Dikilebilir malzemelerden bir tanesi bozuk çıktı. Sonra bozuk olan malzemeyi değiştirdik. Ama onun dışında büyük bir problemle karşılaştık diyemem. Genel olarak tüm etkinlikleri bitirdik.*
>
> *[FC_GR_OE-6]: The Lilypad USB port was broken while sewing the circuit. Since we did not correctly position the LEDs when sewing, the sewing threads were twisted and tangled, so we had to repeat the stitches.*
>
> *[FC_GR_OE-6]: Devreyi dikerken Lilypad USB giriş yeri koptu. Dikiş yaparken LED lerin yerini doğru ayarlamadığımız için dikişlerde karışıklık oldu ve bu yüzden dikişi tekrarlamak zorunda kaldık.*
>
> *[SC_GR_OE-7]: The front button of the Lilypad circuit board was not working. While sewing we broke the Micro USB port that establishes the connections between Lilypad and computer. We replaced a new Lilypad but that also turned out to be broken.*
>
> *[SC_GR_OE-7]: Lilypad devre kartının ön düğmesi kırılmıştı. Dikiş esnasında bilgisayara bağlanan Mikro USB girişi kırıldı. Yeni bir Lilypad taktık fakat o da bozuk çıktı.*

The similar findings were reported in the camp evaluation form where two of the teachers in the first camp and one of the teachers in the second camp stated that some of the issues that were taken place during the design process were about the durability of wearable e-textile technologies. According to teachers, some parts of the sewable electronics like Lilypad were very fragile and, therefore, easily broken. The observations showed that some sewable electronics were either accidentally broken down or burnt out by groups of science teachers during the design process. The researcher of this study had witnessed several such unfortunate accidents or events while helping groups who solicited support and assist.

> *[FC_POST_OE-8]: Lilypads broke down very quickly. Since we could not find a working Lilypad in the last project, our design stayed incomplete. We have not had any other problems.*
>
> *[FC_POST_OE-8]: Lilypad ler çok çabuk bozuldu. Son projelerde Lilypad bulamadığımız için tasarımımız yarım kaldı. Başka problem yaşamadık.*

At the beginning of each camp, groups were informed that since the sewable electronics that they were going to use in each activity were delicate tools, they should be careful while sewing them into the felt or fabric. Despite the instructions and warnings, several groups broke the micro-USB connector of Lilypad USB while trying to connect the Lilypad USB board to a computer. Those groups had failed to complete their projects in time because they had to restart their project design with a new Lilypad USB board. Therefore, it is better to be more careful about the delicate part of sewable electronics because the consequences might be too severe to resolve. The reason teachers had to deal with the problems with sewable electronics could be due to their unfamiliarity with how to use them safely and appropriately because one of the teachers in both the first and second camps stated in the interviews that they hadn't had any experiences with e-textile materials.

> *[FC_INT-5]: We were unfamiliar with activity materials. Since we do not know the materials, the environment seemed complicating. For example, this is the first time I have seen LED light, but in principle it works the same way as other lamps, so plus and minus after all. Or the batteries and the power supply that we used in activities are the same in terms of the way they operate.*
>
> *[FC_INT-5]: Etkinlik malzemelerine yabancıydık. Malzemeleri tanımadığımız için de ortam karmaşık geliyor. Örneğin led ışığını bu şekilde ilk defa gördüm ama prensip olarak diğer lambalar ile aynı şekilde çalışıyor, yani artı ve eksi sonuçta. Ya da pil ve kulladığımız güç kaynağı, bunlarında çalışması aynı.*

> *[SC_INT-1]: We were unfamiliar with the materials, that's why, at first, we had a hard time. Then it became better with the help of facilitators.*
>
> *[SC_INT-1]: Materyalleri tanımadığımız için ilk başlarda çok zorlandık. Daha sonra sizin de katkılarınızla daha iyi oldu.*

The deficiency of materials was another problem reported by teachers in the interviews and open-ended questions. One of the teachers interviewed in the first camp expressed that some of the crafting materials were missing or didn't have sufficient quantity in the camp. Similar problems were reflected in teachers' responses to open-ended questions at the end of the camp. Three of the teachers in the first camp and two of the teachers in the second camp stated in open-ended questions that there was a lack of materials in the camp such as silicon, silicon fiber, stapler, etc.

> *[FC_POST_OE-2]: The materials such as staple, fiber, and cardboard could be added as material.*
>
> *[FC_POST_OE-2]: Zımba materyal olarak eklenebilirdi. Elyaf ve mukavva da.*
>
> *[SC_GR_OE-6]: As silicone was missing, we had difficulty in attaching the materials.*
>
> *[SC_GR_OE-6]: Malzeme olarak silikon eksik olduğu için yapıştırmada zorlandık.*

As indicated above, there were a couple of teachers who thought that the materials available in the camp were not adequate. However, the analysis of survey data showed that a great number of people were content with the adequacy of camp materials. As shown in Table 4.2, numerous teachers agreed (%32.3) or strongly agreed (%35.5) that there was a sufficient number of artistic and design-related materials to craft STEAM designs. Similarly, more than half of the teachers agreed (%25.8) or strongly agreed (%38.7) that the camp was filled with an adequate number of wearable e-textile technologies.

Sewing and Circuitry

The challenges of this section are supposed to be reported under two parts: sewing and circuitry. However, these two parts are so intertwined that they are difficult to be separated. Therefore, they were treated as a single entity rather than separate entities. The study results showed that sewing and circuitry were the two most common challenging parts science teachers experienced in STEAM projects. Four of the teachers in the first camp and three of the teachers in the second camp indicated in the interviews that they had difficulties in stitching and sewing an electronic circuit into the fabric or felt. The same findings were reflected in teachers' responses to open-ended questions. All seven of the teachers in both the first and second camps stated in the group open-ended questions that they struggled to manage the sewing process due to the sewing challenges, and it took more concentration and lots of effort to sew a circuit with conductive thread.

> *[FC_INT-3]: The activities especially require sewing skill. If you do not sew really smooth and carefully, there could be a short circuit. Let us say you did not notice this short-circuit; this makes the solution of the problem very complicated. You say "I wonder where the problem comes from" and have to use the multimeter to check the circuit elements one by one. But if you improve this sewing skill, you can proceed very smoothly. We saw it when we came to the final stage of the camp.*
>
> *[FC_INT-3]: Etkinlikler özellikle dikiş beceri gerektiriyor. Dikişi gerçekten düzgün ve sağlıklı bir şekilde yapmazsanız kısa devre oluşma durumu var. Bir de diyelim ki bunu kısa devreyi fark etmediniz, bu da problemin çözümünü çok karmaşık hale getiriyor. "Acaba problem nereden kaynaklanıyor" diye multimetreyi alıp devre elemanlarını tek tek kontrol etme durumunda kalıyorsunuz. Ama bu dikiş becerisini geliştirirsen çok rahatlıkla sorunsuz ilerleyebiliyorsun. Bunu son aşamaya gelince gördük.*
>
> *[SC_INT-4]: Yes, I had a hard time in sewing. There was quite a difference between our first day and our last day's stitches.*
>
> *[SC_INT-4]: Evet, dikiş dikerken çok zorlandım. İlk günkü dikişlerimiz ile son gunki dikişlerimiz arasında bayağı fark vardı.*

Besides, two of the teachers in the first camp and seven of the teachers in the second camp reported similar sewing issues in their responses to individual open-ended questions. Also, the challenges caused by crafting with conductive thread were profoundly observed during both camps. However, those challenges were commonly associated with circuitry rather than crafting. Because almost all groups struggled to sew circuit components into felts or fabric with conductive thread. The main reason appeared to be due to the conductive thread. Because of its distinctive properties, it is difficult to sew with conductive thread. For example, unlike non- conductive thread, a conductive thread is an uninsulated stainless-steel thread that does not prevent electricity from passing through just like a bare wire. Moreover, as frequently experienced by groups in both camps, the conductive thread has the propensity to tangle and twist easily, causing short-circuiting issues. Also, tying knots and threading the needle with conductive thread could be a challenging and frustrating process, just like observed in both camps.

> *[FC_GR_OE-1]: Since we had a long-length design, there were more doings and staff to manage so we had difficulty in conductivity. Because of our lack of sewing skills, our conductive threads were tangled, which caused a delay in finishing the design.*

> *[FC_GR_OE-1]: Yaptığımız tasarımın uzun olmasından dolayı dikişler uzadı ve iletkenlik kısmında sıkıntı yaşadık. Dikebilme becerilerimizin eksik olmasından dolayı iplerimiz dolaştı. Bu da gecikmeye neden oldu.*

Other sewing challenges were reflected in teachers' statements and observed in both camps. For example, it was observed that some groups made a few long stitches instead of many small stitches to establish circuit connections with conductive thread. However, large stitches then resulted in loose connections that couldn't hold the components in place. Those groups were instructed several times to made small stitches and pull the conductive thread to tighten connections. Some groups just put conductive thread straight between the conductive stitching holes instead of using running stitches. It was obvious that those groups treated conductive thread as if it was a wire. Because of teachers' failure in sewing, some other common issues took place, such as crossing circuitry and short circuits. For instance, one of the reasons causing short circuits was the touching of conductive thread traces. Therefore, it is crucial to insulate conductive thread traces in an e-textile project.

During the e-textile design process, teachers did not only sew circuit components together with conductive thread, but they also engaged in soldering the wire and sewing and cutting felt or fabric using crafting tools. The findings showed that most of the teachers grappled with stitching into both thick and thin felt or fabric. That is, three of the teachers interviewed in the first camp reported that they struggled to stitch circuits into thick and very thin felts with conductive thread. Additionally, all seven of the teachers in the first camp and one of the teachers in the second camp reported similar sewing challenges in their responses to the group open-ended questions. Moreover, four of the teachers in the second camp reported in post-open-ended questions that they had difficulty sewing with thick (5mm) and skinny (1mm) felt fabric. The same problems were observed during both camps, where groups of teachers used different types of fabric felts and regular sewing needles to sew their STEAM projects. For example, there were several occasions in both camps, where groups who used thick felt had conductive thread broken. The reason was because of the amount of force they applied to pull the needle while stitching the thread onto the thick felt. Consequently, this result suggests that it would be better to use mostly 2 mm or 3mm instead of thin (1mm) and thick (5 mm) felts for STEAM projects.

> *[FC_INT-2]: When the felts we used were a little thicker or a little thinner, problems of sewing took place.*
>
> *[FC_INT-2]: Kullandığımız keçeler biraz daha sert ya da biraz daha yumuşak olduğunda dikimde sıkıntılar oluyordu.*
>
> *[FC_INT-2]: We had problems during sewing and decoration because it was our first experience. However, we did not have much problems in the activities followed. On the last day we did not have any problems in our final project. In the early days, I had difficulty with the needle, but now I learn how to sew. I guess I will not have any trouble about sewing after that.*
>
> *[FC_INT-2]: Dikim aşamasında ve nakış işleme sırasında sıkıntılarımız oldu. İlk deneyim olduğu için takip eden diğer etkinliklerde çok bir problem yaşamadık. Son gün kendi yaptığımız final projesinde çok bir sıkıntımız olmadı. Ama ilk günlerde iğne*

konusunda zorluk yaşadık. Şuan öğrendik ama. Bundan sonra da sıkıntı yaşamam sanırım.

[FC_GR_OE-2]: A different material could be used instead of felt because it is difficult to sew circuit pieces into the felt.

[FC_GR_OE-2]: Keçe yerine daha farklı bir malzeme kullanılabilirdi çünkü keçe üzerine dikmesi zor oluyor.

In addition to the findings, observations from both camps indicated that science teachers including males and female had tough times in the sewing process. For teachers, stitching with the conductive thread was challenging than with non-conductive threads. Because the conductive thread is not as flexible as a non-conductive thread. Also, the end of the conductive thread can fray easily, and this could be very frustrating and annoying. The following project desing in Figure 4.6 illustrates an example of how some teachers' sewing and stitches looked like. The idea behind this project is very creative and unique, but the sewing methods applied to the project is not really successful. The project aims to teach students the location of some elements on the periodic table using the color sensor. As seen in the figure, it is impossible to distinguish between the conductive threads.

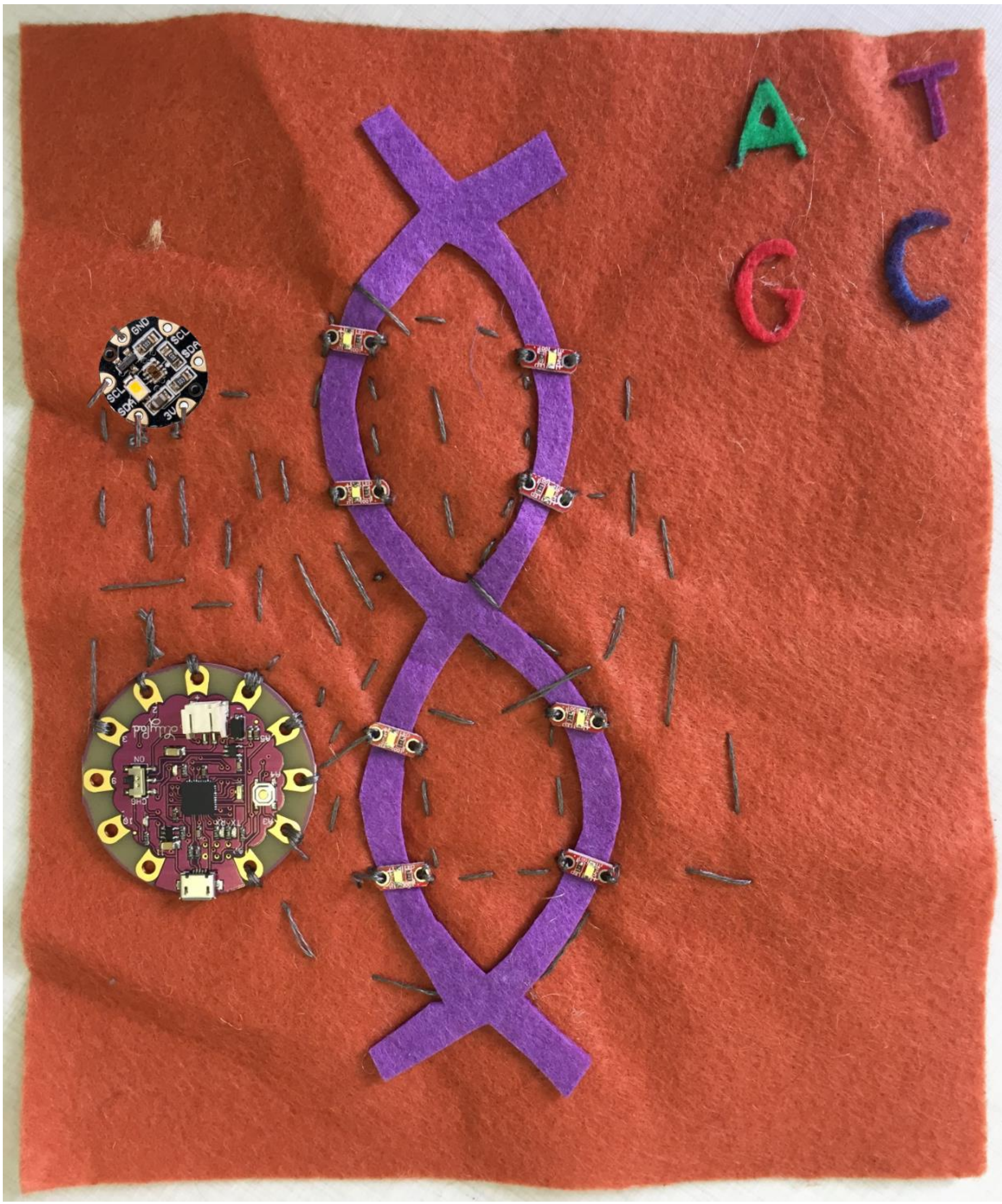

Figure 4.6. A STEAM project about periodic table

Timing and effort

The analysis of qualitative and quantitative data showed that science teachers devoted a great deal of time and effort to the crafting of STEAM activities. Four of the teachers in both the first and second camps expressed in the interviews that time constraints on the design of STEAM activities prevented them from producing full functioning and finished products. The same result was reflected in teachers' responses to the group's open-ended questions. Five of the teachers in the first camp and all seven of the teachers in the second camp reported having difficulty in finishing the project design at the scheduled time. The factors they commonly pointed out for the losing time turned out to be predominantly sewing process and then crafting of the design. It seems that sewing steals a significant portion of time from the overall activity time. The majority of teachers also added that students would face similar and even worse timing challenge when they engage in designing STEAM activities. However, the analysis of survey data collected at the end of each camp showed that the majority of teachers agreed (6 out of 31) or strongly agreed (11 out of 31) that the amount of time allocated to the STEAM activities was sufficient (see Table 4.9).

Table 4.9 The activity time span

Items	*M*	*SD*	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
The time allocated for the activities was sufficient.	5.61	1.36	-	3.23	3.23	12.90	25.81	19.35	35.48
It took me too much time to complete the activities.	3.61	1.67	9.68	25.81	12.90	9.68	29.03	12.90	-
Time passed quickly while doing the activities.	6.58	0.72	-	-	-	-	12.90	16.13	70.97

Similarly, almost half of the teachers disagreed (8 out of 31) or strongly disagreed (3 out of 31) that completing STEAM activities took a long time. It seemed that quantitative results about the challenge of managing activity time were inconsistent with the qualitative results. Nevertheless, as described in detail below, it was observed that in both camps, most of the groups had difficulty in completing their project design within the activity time.

> *[FC_INT-6]: First, the choice of felt fabric and material is important. The amount of time for the design can be increased. We need time to think about design. Since we come to the camp without pre-working and preparing, we have to think about everything about the design during the activities. Obviously, we could not devote much time to the aesthetic and decorative aspects of the design.*
>
> *[FC_INT-6]: İlk önce kumaş ve malzeme seçimi önemli. Tasarım için biraz zaman arttırılabilir. Tasarım üzerinde düşünmek için zamana ihtiyacımız var. Biz etkinliklere çalışmadan ve ön hazırlık yapmadan geldiğimiz için tasarım ile ilgili herşeyi masa da etkinlik sırasında düşünmemiz gerekiyor. Tasarımın estetik ve dekorasyon yönüne açıkçası çok fazla zaman ayıramadık.*
>
> *[SC_INT-1]: Activities took our time. The first activity really took a lot of time. Although easy, it took a lot of time. However, once you know what to do and understand the logic, it does not take much time.*
>
> *[SC_INT-1]: Etkinlikler zamanımızı aldı. İlk etkinlik çok zaman aldı gerçekten. Kolay olmasına rağmen çok zamanımızı aldı fakat sonrasında mantığı anlayınca ne yapacağını bilince çok fazla zaman almıyor açıkçası.*
>
> *[SC_GR_OE-7]: It was challenging for us to have a limited time for the project design. In addition to that, rushing out the design process limits creativity.*
>
> *[SC_GR_OE-7]: Tasarım için kısıtlı zamanın olması bizim için zorlayıcıydı. Ayrıca tasarımı alelacele yapmak yaratıcılığı da kısıtlıyor.*

Besides, the observations from both camps showed that groups struggled to complete some of the STEAM project designs within the period described in the activity sheet. It was observed that the process of sewing with conductive thread took most of the group's activity time. The reason might be due the fact that many of them were new in sewing and stitching sewable electronics into a project with conductive thread using a needle. Furthermore, there were a lot of works for the crafting of the design groups needed to take care. When all these required design tasks are combined, it is likely that the groups couldn't finish their projects in time. However, this does not mean that the time separated for a STEAM activity is quite short. There must be, somehow, time constraints on STEAM activities so that teachers or students can feel compelled to drive their knowledge and skills in multiples fields into a project within the deadline. Otherwise, it would take even days to work on a STEAM project design.

In addition to qualitative data, the survey results showed that half of the teachers struggled to complete their STEAM design within the specified time. It can be seen from the data in Table 4.9 that 34% and 13% of the science teachers, respectively, slightly agreed and agreed that they spent more extended time on their project design. On the other hand, almost the same number of teachers (26% and 10% respectively) agreed and strongly agreed that completing STEAM activities took a longer time. Furthermore, nearly all the teachers agreed (5 out of 31) or strongly agreed (22 out of 31) that they were unaware of how the time passed fast while working on their project design.

Design principles for the implementation of the STEAM activities in the camp

Problems, issues, and challenges are part of a STEAM camp that could be alleviated or completely removed with proper strategies and interventions taking place before, during, and end of the camp.

In the camp, teachers didn't have to write the program code that controls the project circuit; because the workable program code was readily given to each group of teachers once they completed designing their project. Therefore, anyone of science or other teachers could be invited to a STEAM camp irrespective of whether they have prior coding knowledge and experiences if the functional codes are given. On the other hand, if the program codes are not going to be provided in the camp, the camp attendants should not be selected among the teachers who have minimal experience in Arduino coding. However, if teachers with no coding experiences are going to be the camp attendants, they must be given coding knowledge and trained about how to write program codes corresponding to those used in the STEAM hands-on activities.

It is crucial to take into consideration the conditions in the camp place. A STEAM camp should be conducted in a large venue with an air conditioning system that can supply both warm and cold air as well as circulate air in the camp area. Moreover, the camp place should be located in an area where teachers can reach easily and have comfortable transportation facilities. Furthermore, the camp place must have essential technological facilities like easy access to the internet via wireless technologies and electricity. Also, there should be several electrical accessories like power plugs and power extension cable and adequate lighting.

There are three crucial things teachers should keep in their minds and consider while sewing their e-textile design circuit into the felt: the current flow (short circuit), connections (series and parallel circuit), and polarity. To avoid short-circuiting, teachers must be careful that the lines of conductive thread do not touch one another or overlap. Moreover, positive and negative threads should be kept away from each other so that they couldn’t be tangled together and then create a short circuit. Also, stray ends of thread shouldn’t be in contact with each other.

Drawing a design sketch could be considered as a cornerstone of a successful design. Therefore, it is very important to draw a sketch before starting to cut, sew, combine, and choose the design parts. A design sketch should illustrate at least an outline of the project design. In other words, it doesn’t have to be drawn professionally, but it should at least reflect a rough model of the project plan. Science teachers, in general, seem to lack the ability to draw an intermediate design sketch for a STEAM project. Therefore, it could be better to train or give the necessary information to teachers regarding how to draw a basic design sketch that outlines the essential pieces of the design.

Some of the wearable e-textile technologies could be easily broken down and destroyed when they are improperly treated, exposed to short-circuiting, and powered by overvoltage. Among the wearable e-textile technologies used in the camp, Lilypad Arduino USB is the one that could mostly cause trouble during the project design. The micro-USB connector is the most fragile part of the Lilypad Arduino USB board. It should be noted that the micro-USB connector could be easily broken when the Lilypad Arduino board isn't carefully attached to the computer. When that part is broken, Lilypad Arduino board itself becomes garbage. To keep not only Lilypad Arduino but also other electronics intact throughout the project design, they must be carefully sewed into the fabric or felt.

Furthermore, some of the sewable electronics might be already broken or improperly working. In other to detect such malfunctioning electronics, teachers must test them to explore whether they are fully functional before using it in their STEAM projects. Besides, the necessary information should be given to teachers about the wearable e-textile technologies, how they function, and how Lilypad Arduino is connected to the computer in advance of the camp.

Teachers must have fundamental sewing skills and some practices with conductive and non-conductive threads in advance of the camp. There are some essential sewing tips that teachers should know or familiar with before the camp, such as how to sew circuits together with conductive thread, to make running or hidden stitch, to secure the connections between circuit component's sew tabs, treat a needle, and to tie a knot. Because teachers without prior sewing practices with conductive thread are very likely to spend more time and put more effort during the whole project design, which could be frustrating, discouraging, and overwhelming.

The camp should be equipped as many varieties of materials as possible because the absence of materials could interfere with the type of design that teachers have planned to produce. Besides, in their final group project, teachers may opt to use different e-textile technologies then they used in their previous STEAM projects. Moreover, bringing various materials to the camp could drive teachers to come up with an innovative design.

Different types and assorted colors of fabrics and felts can be used for STEAM projects as long as they are neither very thick nor skinny, because the thick and thin fabric could impede the whole sewing process. It should be noted that it is challenging to pass a needle through a 5mm thick felt. Similarly, a 1mm thick felt does not allow to do smooth sewing. In the camp, instead of 1mm and 5mm thick felt, it is advised to use either 2 mm or 3mm thick felt. Moreover, it is better to use thick fabrics or clothes if any one of them is to be used in the camp.

Design, sewing, and circuitry are interwoven in STEAM activities. That is, these three concepts are so closely intertwined that a significant change in one concept could result in a substantial effect on other concepts. It could be hard to draw boundaries among these three concepts in a STEAM project design. Therefore, teachers or other people who want to develop or adapt similar activities in different contexts should consider the strong level of connection across design, sewing, and circuitry.

4.5.1.3 Suggestions for improving the design and development of activities

This theme covers a detailed description of the suggestions and recommendations given by science teachers on how to improve the design and development of STEAM activities. In order to seek appropriate remedies and amendments to problematic and ineffective parts of STEAM activities, science teachers were asked to describe their hands-on and practical experiences in both camps. The teachers' suggestions of STEAM activities are reported below under the three sub-themes: application and implementation, assessment of performance and learning gain, and interdisciplinary collaboration.

Science teachers gave a wide variety of constructive, practical, and valuable suggestions about the application and implementation of STEAM activities not only in the camp but also in the school environment. The dozens of suggestions given for this sub-theme is unified and grouped into sixteen different parts. These sixteen parts are separately reported below.

4.5.1.3.1 Assisting and guiding the design process

The information from the pilot study informed the main research about the number of facilitators needed to assist and guide the groups of science teachers in the process of project design. The pilot studies clearly showed that more experienced facilitators were required to facilitate the design process so that the groups could handle the problems with the help of assistance provided. Therefore, the number of facilitators was increased in both camps followed. In both camps, graduate students and undergraduate students assisted and supported groups of science teachers in their STEAM project design. The analysis of quantitative data, which were collected through post-survey at the end of each camp, showed that science teachers in both camps were pleased with the assistance and helps provided by facilitators. For instance, 13% and 84% of the teachers, respectively, agreed and strongly agreed that the support and assisting given by facilitators in the camp was satisfactory (see Tabel 4.10).

Table 4.10 Assistance and guidance

	M	*SD*	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
When I had difficulties during the camp, I could find someone to help me immediately.	6.84	0.45	-	-	-	-	3.23	9.68	87.10
The support provided in the camp is adequate.	6.81	0.48	-	-	-	-	3.23	12.90	83.87
The assistants who provided support at the camp had sufficient knowledge and skills.	6.77	0.50	-	-	-	-	3.23	16.13	80.65
I could do the activities thanks to the support and help provided in the camp.	6.68	0.60	-	-	-	-	6.45	19.35	74.19

Similarly, as shown in Table 4.10, a great number of the teachers (19% and 74% respectively) agreed and strongly agreed that they could be able to successfully make their STEAM design with the help of the support and assistance provided by facilitators throughout the camp. Furthermore, the survey results indicated that all of the teachers found the facilitators equipped with the sufficient knowledge and skills that were necessary to deal with the problems and issues taken place during the camp. In all, 97 % of the teachers agreed or strongly agreed that the facilitators who assisted the groups during the camp had adequate knowledge and skills. Likewise, 10% and 87% of the teachers, respectively, agreed and strongly agreed that they could easily find someone to help once they needed urgent and immediate assistance.

However, it might be better to assign at least an assistant to one or two groups, especially when the groups are composed of students rather than teachers. But, this seems to largely depend on the availability of persons who have enough knowledge and practical and technical skills to be able to assist interdisciplinary hands-on tasks like STEAM activities.

The nature of group dynamics in STEAM activities enabled groups to seek for assisting not only from facilitators but also from the other groups. The observations in both camps showed that science teachers did solicit not only help from assistants but also their peers and other group members. However, they tended first to seek help or ask for information from assistants than the other sources.

4.5.1.3.2 Setting activity content

The part of complementary amendments and adaptations to the activity content is divided into three sections: problem scenarios, circuit diagram, and content sequence. Science teachers' suggestions for each of these sections are reported below.

Circuit Diagram

The study result showed that science teachers commonly agreed that it was important and somehow necessity to attach the circuit diagram to the activity content. However, there were some variations in their opinions regarding the types of situations where the circuit diagram should be excluded or included from the activity sheet. Related to the exclusion of the circuit diagram, all six of the teachers in the first camp and one of the teachers in the second camp expressed in the interviews that circuit diagram may be excluded if students had established sufficient circuitry knowledge or acquired some prior experiences.

> *[FC_INT-1]: This subject should definitely be included in the curriculum. Definitely, because I have never designed a circuit like this before. This is even the first time I have ever seen a Lilypad. Therefore, it is not possible for me to know how to make*

connections without an instructional schema. If there is not any instructional schema, it should be explained how to make the connections. In this case, we need to take notes about the connections. However, if there is an instructional schema, we do not need to take notes. By using the information in the schema directly, we can make connections very easily.

[FC_INT-1]: Bu konu kesinlikle müfredata dahil edilmelidir. Kesinlikle… Çünkü belirtilen şekilde bir devreyi daha önce hiç tasarlamamıştım. Bir lilipadi bile ilk defa görüyorum. Bu nedenle, yönlendirici bir şema olmadan bağlantıların nasıl yapılması gerektiğini bilmem mümkün değildir. Eğer yönlendirici şema yoksa, bağlantıların nasıl yapılması gerektiği anlatılmalıdır. Bu durumda, bağlantılar ile ilgili notlar almamız gerekir. Fakat yönlendirici bir şema var ise not almamıza da gerek kalmaz. Direkt olarak bu şemadaki bilgileri kullanarak çok rahat bir şekilde bağlantıları yapabiliriz.

[SC_INT-2]: The activities should be given at first. In the school textbooks, generally, without implementing the activities, it is asked to, first, give theoretical information, but students do not want to do so. At first, the student will see how easy the activities are so that he understands that these activities are simple. Therefore, I think that the circuit diagram must be given at the begining.

[SC_INT-2]: İlk başta etkinlikler verilmeli. Genelde MEB'in ders kitaplarında etkinlikler verilmeden ilk olarak teorik bir biçimde anlatılması isteniyor fakat çocuklar bunu yapmak istemiyor. İlk başta etkinlikleri yapmanın kolay olduğunu görecek ki, bu etkinliklerin basit olduğunu anlasın. Bu yüzden, devre şemasının mutlaka başta verilmesi gerektiğini düşünüyorum.

One of the teachers in both the first and second camps stated in interviews that there should be a circuit diagram for junior students (5 and six grades), but for senior students (7 and eighth grades), it may not be necessary to include. Teachers explained that senior students, compared to junior students, are supposed to have already gained circuitry knowledge and understanding of the circuit. Therefore, there would be no need to show them the circuit diagram.

[FC_INT-4]: It may not be a problem not to provide circuit diagrams to 7th and 8th grade students, but it would be better if such diagrams are presented to 5th and 6th grade students because 5th and 6th grade students are still very young. So, maybe

with the young students we can do the simple activities that we did in the first day of the camp.

[FC_INT-4]: 7. ve 8. sınıf öğrencilerine devre diyagramı sunulmaması sıkıntı yaratmayabilir fakat 5. ve 6. sınıf öğrencilerine bu tür diyagramlar sunulursa daha iyi olur. Çünkü, 5. ve 6. sınıf öğrencileri henüz çok küçük yaştalar. Bu nedenle, belki de onlarla kampın ilk günü yaptığımız basit düzeyde aktiviteler yapabiliriz.

[SC_INT-4]: Well, it could be like this. Presenting circuit diagrams to 5th grade middle school students may be a correct method. However, instead of giving such schemes directly to 8th grade students, they can be provided with an internet-enabled computer where they can find this information. In this way, these students have the opportunity to explore the information they need firsthand. Teachers guide them through the challenges they face in this process.

[SC_INT-4]: Yani şu şekilde olabilir. Ortaokul 5. sınıflar için devre şemasının verilmesi uygun olabilir. Fakat 8. Sınıflara devre şeması vermek yerine, onlara bu bilgileri bulabilecekleri internet bağlantılı bilgisayarların olduğu ortam sağlanabilir. Bu sayede, bu öğrenciler ihtiyaç duydukları bilgiyi ilk elden araştırma şansına da sahip olmuş olurlar. Öğretmenler, bu süreçte öğrencilere rehberlik edebilir.

Content Sequence

The organization and sequence of the content in a STEAM activity run parallel to the design thinking phases. Science teachers suggested some additions to the existing STEAM activity content. For instance, one of the teachers in both the first and second camps reported in the group open-ended questions that the introductory information given at the outset of the camp about the implementation of STEAM activities should be increased and elaborated. In fact, at the beginning of each STEAM activity, science teachers were informed about the activity including the materials to be used and the phases to be followed during the project design. However, it seems that those explanations were not adequate.

[FC_GR_OE-1]: There could have been detailed explanation of how to carry out the activities.

[FC_GR_OE-1]: Etkinliklerin nasıl yapılacağı ile ilgili detaylı açıklama verilebilirdi.

[SC_GR_OE-1]: The content of the activities can be presented orally to the participants.

[SC_GR_OE-1]: Etkinliklerin içeriği katılımcılara sözlü bir şekilde sunulabilir.

Besides, three of the teachers in the first camp reported in the interviews that it would be better to allow each group to have a presentation about their project design at the end of each activity. Furthermore, one of the teachers in the second camp stated in the interviews that all the STEAM projects designed in the camp could have been exhibited or showcased in a large hall. The teacher explained that there should be an exhibition showcasing all the project design crafted in the camp, which would be very useful and make groups take the design process seriously.

[FC_INT-2]: I think that a presentation could have been added to the last part of each activity to improve the functionality of the camp. That seemed to be the only missing part. Though actually, the number of the activities was too much, and the activity time was limited. I attended a different activity before about sustainability. At the end of the activity, everyone came out and told us about the purpose of his product. Doing this kind of work in this camp may drive participants to attend a purpose-oriented work.

[FC_INT-2]: Bence kampın işlevselliğini arttırmak için her etkinliğin son kısmına sunum eklenebilirdi. Bir tek o eksiklik gibi geldi bana. Gerçi etkinlik sayısı çok fazla ve zaman kısıtlıydı. Amacı sürdürülebilirlik olan farklı bir etkinliğe katılmıştım. Orada etkinlik sonunda herkes çıkıp yaptığı ürünün amacını anlattı ve bunu değerlendirdik. Belki bu kampta böyle bir çalışma yapılması insanların amaca yönelik çalışmasını sağlayabilir.

[SC_INT-1]: I think that if there is an exhibition at the end of the camp, participants will take their works more seriously. Working with more crowded groups means more ideas, color, work, knitting, and sewing. I think that this will contribute more than enough, and the camp will be more extensive. For example, in STEM Expo events held every year, why would not these activities be there? Why should not teachers and students prepare a project about this STEAM? In addition, new workshops are continuously opening. People will really be interested in wearable technology.

For example, these activities in the camp can be sent to fairs in the form of a workshop. There are already too many teachers to volunteer for this workshop, and it attracts a lot of attention. Such activities that mix science and art are rare. So, if you think of doing something like these, please let us know.

[SC_INT-1]: Bence kampın sonuna sergi konulursa bu işin daha ciddiye alınacağını düşünüyorum. Daha kalabalık gruplarla çalışılması, daha fazla fikir, renk, işleyiş, örgü ve dikiş demektir. Bence bu fazlasıyla bir şeyler katacaktır ve kamp daha kapsamlı olacaktır. Mesela her sene yapılan STEM Expo etkinliklerinde, böyle etkinlikler neden olmasın? Öğretmen ve öğrenciler neden bu STEAM hakkında proje hazırlamasın? Ayrıca sürekli atölyeler açılıyor. İnsanlar giyilebilir teknolojiye gerçekten çok ilgi duyacaklardır. Mesela, kamptaki bu etkinlikler bir atölye şeklinde fuarlara gönderebilir. Bunun için gönüllü olacak çok fazla öğretmenler olur ve çok ilgi çeker. Böyle bilim ve sanatı birbirine karıştıran etkinlikler nadir. Bu yüzden eğer bunu düşünürseniz ve bize de haber verin.

The seven of the teachers in both the first and second camps stated in post-open-ended questions that the camp should focus more on coding with the Lilypad Arduino. In other words, what teachers commonly emphasized in their responses to open-ended questions was to devote more time to coding instead of merely focusing on some overlapping domains such as art, fashion, crafting, and circuitry. Analysis of qualitative and quantitative data showed that science teachers' suggestions for the development of the camp corresponded to their expectations for attending the camp. That is, teachers' responses to pre-open-ended questions revealed that eight of the teachers in the first camp and three of the teachers in the second camp had expected to learn Arduino programming language and to get familiarity with Arduino development environment in the camp. However, the analysis of survey data showed that many teachers (29% and 32% respectively) agreed and strongly agreed that they learned how to make coding with Lilypad Arduino in the camp (see Table 4.2).

[FC_POST_OE-7]: I was expecting to focus more on coding. However, I worked more on the design. I would like to have activities involving more Arduino coding. At least one day of the camp could be allotted to teaching coding.

[FC_POST_OE-7]: Daha çok kodlama üzerinde yoğunlaşmayı bekliyordum. Tasarım ile daha çok uğraştım. Arduino kodlama etkinliğinin daha fazla olmasını isterdim. En azından bir gün kodlama dersi alınabilirdi.

[SC_POST_OE-8]: The coding section could be increased a little bit more. The design part was more emphasized in the activities.

[SC_POST_OE-8]: Kodlama kısmında biraz daha ağırlık verilebilir. Tasarım kısmı daha çok ön planda olan etkinlik oldu.

One of the teachers in the second camp stated in pre-open-ended questions that at the end of the camp, teachers should develop a lesson plant using their camp experiences and professional subject knowledge. This suggestion sounds promising because it would allow teachers to present and showcase their abilities to integrate STEAM activities or experiences into their course plans.

[SC_POST_OE-11]: If the camp time was a little longer, teachers would be asked to make a lesson plan about the STEAM activities as the last activity. After evaluating the course plans, the certification process would begin.

[SC_POST_OE-11]: Kamp zamanı biraz daha uzun olsaydı en son etkinlik olarak öğretmenler STEAM etkinliği ile ilgili bir ders planı yapmaları istenirdi. Bu ders planının değerlendirilmesi sonucunda da sertifika verme süreci başlardı.

Problem Scenarios

Science teachers commonly agreed that there should be an activity scenario. According to them a problem scenario has the capability of involving groups of teachers or students in a problem situation in which they engage in making a design that could solve the problem. However, they suggested some revisions to the activity scenarios. One of the teachers in both the first and second camps expressed in the interviews that some activity scenarios should be adapted in terms of clarity and length. The same suggestion was reflected in the group open-ended questions. One of the teachers in the first camp stated in the group open-ended questions that some of the activity scenarios were long for students. Therefore, those long scenarios should be shortened.

[FC_INT-4]: I thought that there might not be needed to have such a long scenario in some place because the structure of the scenario can change according to the conditions. Actually, we cannot give scripts every time. In a 36-students classroom, it would be difficult to expect students to read the scenario. So, scenarios can be as short and concise as possible. We can give a brief information that helps students quickly understand the problem. Most students won't listen when we increase the length of the scenario.

[FC_INT-4]: Bazı yerlerde bu kadar uzun bir senaryoya gerek var mıydı, diye düşündüm. Çünkü ortama göre senaryonun yapısı de değişebiliyor. Aslında her seferinde senaryo veremiyoruz. 36 kişilik bir sınıfta öğrencilerin senaryoyu okumalarını beklemek zor olur. Bu yüzden senaryolar olabildiğince daha kısa ve öz olabilir. Hızlı bir şekilde problemi anlayacakları kısa bilgiler verilebilir. Senaryoyu uzattığımız zaman çocukların çoğu dinlemez çünkü.

[SC_INT-2]: Some of the scenarios were too long. This camp was suitable for teachers as it was intended for them, but if I did this activity for the students, I would not keep the scenarios that long. I can also give scenarios to the students through animation, PowerPoint presentation or simply a story book. Again, this can be changed according to the age group and the creativity of the teacher. The scenarios are suitable for teachers, but I think they can be shortened a bit more for the students.

[SC_INT-2]: Senaryoların bazıları çok uzundu. Bu kamp öğretmenler için düşünülen bir etkinlik olduğu için uygun geldi. Ama öğrenciler için bu etkinliği yapsam senaryoları o kadar uzun tutmam. Ben çocuklara senaryoları animasyonla, powerpoint sunumuyla ya da en basitinden bir hikâye kitabıyla da verebiliyorum. Yine bu da yaş grubuna göre, öğretmenin yaratıcılığına göre değiştirilebilir. Senaryolar öğretmenler için uygun ama öğrenciler için biraz daha kısaltılabilir diye düşünüyorum.

Science teachers contented with the current activity scenarios. However, when it comes to the application of these activities by students, they put forward some adaptations that might be useful to apply. Three of the teachers in the first camp and one of the teachers in the second camp expressed in the interviews that activity scenarios should be geared towards some student-related factors like grades, interests, and life experiences. They explained that students would show more interest in activity scenarios if those scenarios appealed to their' imagination, current life, and surroundings or district. In summary, teachers thought that it would be better to take the student's current life, surroundings, interests, and district into consideration when forming an activity scenario. They also added that the scenarios should be scripted in a way that appeals to students' imagination.

> *[FC_INT-3]: I think that the activity scenarios should be tailored specifically to where students live. It is very difficult for a child in Ankara to feel the same problem as a child in the Black Sea region. It is very important that certain conditions are met, and, in particular, that common thinking is achieved because these students face very different problems in their regions. Therefore, a region-specific scenario should be created.*

> *[FC_INT-3]: Senaryolar özellikle bulunan yöreye göre düzenlenmesi gerekir diye düşünüyorum. Ankara'daki bir çocuğun, Karadeniz bölgesindeki bir çocukla aynı problemi hissetmesi çok zordur. Belirli şartların sağlanması yani özellikle ortak düşüncenin sağlanabilmesi çok önemli. Çünkü bu öğrenciler birbirinden çok farklı sorunlarla karşılaşıyor. O yüzden bölgeye has senaryo oluşturulmalı.*

> *[SC_INT-3]: There are many electrical devices used in daily life. There is a doorbell and a door automat, for instance. You read the card, then the door opens and closes. You can bring such devices, show them to the students, and let students to examine them, and after that a similar project may be requested from the students. As a result, the child becomes curious about what he saw and the materials used, and then maybe he can develop something new. Going through such examples can be better and enrich the student's ideas. For example, many students do not know how the bell works and what components it is made of. The materials inside the bell can be extracted so that students can observe and examine them. After that, the student could be asked for his own projects and encouraged to contemplate about the questions like how can I use it in a different place? Or what else can I do out of the given circuit diagram? and so on.*

> *[SC_INT-3]: Günlük hayatta kullanılan birçok elektrikli cihaz var. Kapı zili ve kapı otomatiği var mesela. Bunlarda kartı okutuyorsun sonra kapı açılıyor ve kapanıyor. Bu tarz cihazları getirip, öğrencilerin gözleri önünde açıp, onları inceleyerek öğrencilerden öyle bir proje istenebilir. Sonuçta çocuk gördüğü şeyi ve hayatında kullandığı malzemeleri merak eder ve bunun üzerinden belki de yeni bir şeyler geliştirebilir. Bu örnekler üzerinden gidilirse daha güzel olabilir ve öğrencinin fikrini*

zenginleştirebilir. Mesela birçok öğrenci zilin nasıl çalıştığını, içinde ne olduğunu bilmiyor. Ama bir adet zil getirip öğrencilerin önünde içini açıp gösterilebilir. Ondan sonra onunla ilgili projeleri istenir. Bak bu böyle çalışıyormuş demek ki deyip, öğrenci şu şekilde teşvik edilebilir: Bunu nasıl farklı bir yerde kullanabilirim? Devre şemasının dışına çıkıp daha farklı neler yapabilirim?

The consistency of discipline-based objectives with the educational program

The STEAM activities are designed to include a diverse set of objectives from multiple disciplines at the intersection of crafting, circuitry, and design. Two of the teachers interviewed in the first camp suggested that discipline-based objectives that address skills and abilities in various domains should be incorporated into STEAM activities. They thought that the discipline-based objectives in STEAM activities should be consistent with the objectives in the educational program or curriculum. The STEAM learning objectives must be geared specifically to the needs of students in multiple subjects. However, as reported in the following sections by most of the teachers, the attempts to teach different subjects through STEAM activities would require a lot of collaborative efforts among teachers in multiple disciplines, curriculum developers, and even policymakers.

[FC_INT-2]: In the program, the skills and activities that the activities address should be clearly described. For example, as art objectives, the perception of color is acquired here. For a light sensor, for example, something that the child paints can be used.

[FC_INT-2]: Programda etkinliklerin hangi becerilere hitap ettiği kazanım kazanım belirtilmeli. Örneğin sanat kazanımları olarak renk algısının öğretilmesi sağlanıyor. Işık sensörü kullandığımızda mesela çocukların kendi boyadıkları bir şeyi kullanabilirsiniz.

Besides, they added that in a STEAM activity, a student should be able to spot the STEAM connections like what science skills are used and what is the role of engineering in the activity. According to the teachers, the STEAM connections should be so apparent and transparent that students could fell those connections together with their boundaries.

[FC_INT-5]: How scientific knowledge and engineering knowledge were used in these activities? The relationship between technology and science needs to be intertwined throughout the activities. Students may not distinguish these relationships. Therefore, I think the teacher should emphasize them. To exemplify, here in STEAM activities we used scientific knowledge about electricity, but what role did the engineer play here? The engineer made a lighthouse to make our lives easier. What did he use? He used technology. How did technology evolve? It emerged from the scientific discoveries. So, what did the development of technology provide scientists? I think these links should be emphasized during the activity and the course.

[FC_INT-5]: Bu etkinliklerde bilimsel bilgi ve mühendislik bilgisi nasıl kullanıldı? Teknoloji ile fen bilimleri arasındaki ilişki etkinlik süresince iç içe olması gerekiyor. Yani öğrenciler bu ilişkileri ayırt edemiyor. Dolayısıyla öğretmenin bunları vurgulaması gerektiğini düşünüyorum. Örneğin, elektrikle ilgili bilimsel bilgiyi burada kullandık peki, mühendis burada ne yaptı? O da hayatımızı kolaylaştıracak bir deniz feneri yaptı. Ne kullandı? Teknolojiyi kullandı. Peki teknoloji nasıl gelişti? Bilim insanlarının dayandırdığı temellerden ortaya çıktı. Peki teknolojinin gelişmesi bilim insanlarına ne sağladı? Etkinlik ve ders süresince bu bağlantıların vurgulanması gerektiğini düşünüyorum.

4.5.1.3.3 Using instructional strategies

4.5.1.3.3.1 Development of arts and creativity

The STEAM activities enabled teachers to elicit and grow their art skills during the project design. It is of great importance to possessing some art skills because they can help craft an aesthetic project design. The analysis of teachers' responses to the interviews and open-ended questions revealed two strategies that could give impetus to the development and use of art skills in STEAM activities. One of the strategies that were suggested by two of the teachers interviewed in the first camp was to give groups a degree of autonomy and control over the project design, letting them choose whatever materials or sewable electronics they wanted to use for their project design. A teacher in the second camp pointed out the same view in group open-ended questions. In summary, science teachers explained that in the initial activities there should be some constraints or limitations on the project design including use and selection of the materials, but as groups were getting used to the design process and the way of using materials in the activities, those limitations could be alleviated gradually in the subsequent activities.

> *[FC_INT-1]: Well, something like this. You can ask students to design a thermometer, but the sort of designs that students can make on the thermometer will be limited. However, if you present the subjects to the students and leave them free during the activity, more diverse designs may emerge. I prefer inductive methods in these things because it is better to start learning something little by little. You may think like walking. First, he crawls, then he takes a little step, and after that he runs. This method is the healthiest one.*
>
> *[FC_INT-1]: Yani şöyle bir şey. Çocuklardan bir termometre tasarlamalarını isteyebilirsiniz ama çocukların termometre üzerinde yapabilecekleri tasarımlar sınırlı olacaktır. Ama çocuklara konuları sunup etkinlikte serbest bırakırsanız daha çeşitli tasarımlar çıkabilir. Yani ben bu tarz şeylerde tümevarımsal yöntemleri daha çok tercih ediyorum çünkü ufak ufak öğrenmeye başlamak daha iyidir. Yürümek gibi düşünebilirsiniz. Önce emekler, sonra küçük küçük adım atar, ardından da koşar. Bu yöntem en sağlıklı olanıdır.*
>
> *[FC_INT-5]: Students are already very creative. After a while in the education system, we limit their creativity. It could be that: after giving scientific knowledge and drawing a design scheme, students can go shopping for materials for the design they plan to make. Each student can take their own materials and design accordingly. Students should be free to choose materials to use in the classroom. When the students use the materials that we have brought to the class, it would be as if we have chosen the materials instead of them. We may let them bring activity materials from home or somewhere outside.*
>
> *[FC_INT-5]: Çocuklar zaten çok yaratıcı. Eğitim sistemi içerisinde bir süre sonra biz onların yaratıcılığını kısıtlıyoruz. Belki şu olabilir, bilimsel bilgiy verilip tasarım şeması çizildikten sonra öğrenciler alışverişe gidebilir. Her öğrenci kendi malzemesini alıp ona göre tasarım yapabilir. Öğrenciler sınıfta kullanacağı malzemeleri seçmede özgür olmalı. Sınıfa getirdiğimiz malzemeleri öğrenciler ihtiyaç duydukları kadar*

aldığında yine malzemeleri onlar yerine biz seçmiş gibi olacağız. Belki evden malzeme getirmelerine, ya da dışarıdan malzeme getirmelerine izin verebiliriz.

The other strategy proposed by three of the teachers interviewed in the first camp was to inspire groups with the exemplary project designs. The same idea was suggested in teachers' responses to group open-ended questions as well. One teacher in the first camp stated that there could have been some project exemplars demonstrated to the groups in the camp. Teachers thought that demonstrating previously designed project exemplars and organizing field trips could stimulate students' thinking and help them form some initial ideas about the project design they were going to make.

> *[FC_INT-1]: For example, several ready-made projects may be shown, but students should be prohibited from doing the same designs. Telling students to design projects that are similar to projects shown to them can arouse something in students' mind.*
>
> *[FC_INT-1]: Örneğin, birkaç tasarım örneği gösterilip aynısının yapılması yasaklanabilir. Bu tasarımlara benzer bir tasarım denildiğinde, çocukların kafasında bir şeyler canlanabilir.*
>
> *[FC_INT-2]: I do not know. As a step further, maybe, a little trip with the kids can be done. During these trips, for example, the students at first can superficially see the door sensors that trigger the door to open and close.*
>
> *[FC_INT-2]: Bilmiyorum, belki daha ileri bir basamak olarak, çocuklarla ufak bir gezi yapılabilir. Bu gezilerde öğrencilerin mesela açılıp kapanan kapılardaki sensörleri vs. ilk başta örtülü bir şekilde görmeleri sağlanabilir.*
>
> *[FC_GR_OE-1]: The ideas could have been formed through exemplary designs that had been previously prepared.*
>
> *[FC_GR_OE-1]: Önceden yapılmış tasarımlarla fikir oluşumu sağlanabilirdi.*

The role of creativity and originality is as crucial as of sewable electronics in a STEAM project design. Creativity is the ability to use skill and imagination to produce a project design that is new and original in terms of the way it is crafted. In the interviews, one of the teachers in the first camp and three of the teachers in the second camp pointed out some instructional practices that could be used to stimulate artistic creativity in the design of the STEAM project. For instance, they thought that the STEAM activities should be designed in such a way that the project designs that were crafted could bring solutions to the real-life problems prevailing in the society or the surroundings, not to the problems made up or invented. Also, they stated that since sewing, art, and crafting appeals to females more than males, female students were likely to have more interest in STEAM activities than male students. Therefore, STEAM activities should be designed to attract both sexes equally.

> *[FC_INT-2]: For example, there are fire sensors at home. A ready-made fire sensor design can be introduced and something similar to this design can be asked to create in the activity. When the product design is finished, you can put the two designs side by side and tell the student that this is a simple version of the fire sensor and you have the ability of designing it. This method can be more effective to give the child engineering knowledge and a sense of his own making abilities.*
>
> *[FC_INT-2]: Mesela evlerde olur ya yangın sensörü. Örnek bir tane yangın sensörü getirilip buna benzer bir şey yapılabilir. Ürün çıktığında ikisini yan yana koyup, çocuğa bu tasarladığın yangın sensörü basit bir versiyon ve sen bunu yapabildin demek gerekiyor. Bu çocuğa yapabilme duygusunu kazandırmak ve mühendislik bilgisini vermek için daha etkili olabilir.*
>
> *[SC_INT-5]: The STEAM activities are intriguing but male students may have less interest than female students, because the necklace is generally used by female students.*
>
> *[SC_INT-5]: Etkinlikler bu şekilde ilgi çekici fakat erkek öğrencilerin ilgisi kız öğrencilerine göre daha az olabilir. Çünkü kolye genelde kız öğrencilerin kullandığı bir takıdır.*

The following project, shown in figure 4.7, was designed by a group of teachers whose members were all females. The group crafted a baby romper that lit red-colored LEDs and created noise when the sensor attached to romper detected a critical temperature level. The reason the female-dominated group came up with such a creative project design was because one of the teachers in the group was going to have a baby and doing some preparations for it. Besides, it seems that the group regarded baby wetting an inevitable problem to face and attempted to solve it with an e-textile design. Like this project, the design to be created by either teachers or students should be tailored to their interests, cultures, and surroundings.

Figure 4.7. A baby romper STEAM project design

In both camps, a limited number of sewable electronics were given to each group for each STEAM activity. A science teacher interviewed at the first camp stated that placing restrictions on the use of sewable electronics would hinder creativity. According to that teacher, there shouldn't be any limitation of materials usage. However, the underlying logic or premise of interdisciplinary approaches (e.g., STEAM activities) is to create a cost-effective design using fewer materials available in the environment as possible. Therefore, it might not be useful to put constraints on the use of sewable electronics than to allow groups to use as many materials as they want.

> *[SC_INT-4]: First, I think that there should not be tight constraints on the use of materials. So instead of giving us two LEDs, it could be like you can get as many LEDs as you want, or you can get as much material as you want in your project design. If it is done this way, I think that creativity would be more visible.*
>
> *[SC_INT-4]: Ben öncelikle malzeme konusunda sınırlama olmaması gerektiğini düşünüyorum. Yani bize 2 tane led vermek yerine, istediğiniz kadar led alabilirsiniz ya da istediğiniz kadar malzemeden alabilirsiniz şeklinde olmalı. Eğer bu şekilde yapılırsa yaratıcılık daha çok ön plana çıkar diye düşünüyorum.*

One of the teachers in the first and second camps expressed in the interviews that that exemplary design projects should be shown to the groups in advance of the activity to inspire and help them develop ideas about their project design. Teachers thought that demonstrating the design examples that had been already produced would inspire groups to use more art skills in their project design.

> *[SC_INT-1]: I think exemplary e-textile designs should be shown at the beginning of the related activity. The remaining design section can then be left to the imagination and creativity of the group. For example, the activity could proceed with a question like this: "What design would you do in your project?". The last activity in the camp was something like that. At the beginning of the activity, if you had asked me to make a particular design, I would not have done it. However, right now I have some design ideas in my mind. If such a method was used in the first activity, I would not be able to design it because I did not know what we were dealing with and how to sew the Lilypad into fabric.*
>
> *[SC_INT-1]: Bence başlangıçta örnek tasarımlar verilmeli. Daha sonra kalan tasarım bölümü hayal gücüne ve yaratıcılığa bırakılabilir. Örneğin "Siz ne yapardınız?" şeklinde devam edebilir. Kamptaki son etkinlik öyle bir şeydi. Etkinlik başında bana bu tasarımı yap deseniz, ben böyle bir şey yapamazdım ama şu an kafamda bazı fikirler var mesela. İlk etkinlikte böyle bir yöntem kullanılsaydı tasarımı yapamazdım çünkü mevzunun ne olduğunu ve Lilypad leri nasıl yerleştireceğimi bilmiyordum.*

4.5.1.3.3.2 Emphasizing on subject-based concepts

The STEAM activities focus on the acquisition of concepts in science (particularly the basic concepts of electricity and electric circuits) at the intersection of arts, making, crafting, and designing. Three of the teachers interviewed in the first camp stated that in STEAM activities, the priority should be given to the learning of the abstract concepts. Furthermore, teachers proposed that students should be exposed to different STEAM activities of the same types that were targeting the learning of some particular concepts and abilities until they succeeded in acquiring them. Because of its nature, STEAM activities can afford the learning of abstract subjects that are tough to grasp. It might even be more fruitful to focus largely on abstract concepts rather than the factual concepts in STEAM activities.

> *[FC_INT-3]: The activities are good systems for further self-improvement, but they can be simplified. Instead of one activity on the same subject, several different activities can be designed. Once the student has learned to connect the circuit by sewing it, he can switch to, let us say, sensor. After learning how to connect this sensor, he discovers how the sensor works. Afterwards, he is expected to produce another product by questioning where he can use what he has learned in his daily life. It is not a problem for us to move from one activity to another immediately, but the student may have difficulty of understanding. For this, two or three activities should focus on the same subject, then the next activity can be given.*
>
> *[FC_INT-3]: Etkinlikler kendini daha da geliştirmek adına iyi bir sistem ama biraz daha basitleştirilebilir. Aynı konuda bir etkinlik yerine birkaç farklı etkinlik tasarlanabilir. Kişi devreyi dikerek birbirine bağlamayı öğrendikten sonra başka bir sensöre geçiş yapabilir. Bu sensörü de bağlamayı öğrendikten sonra sensörün nasıl çalıştığını keşfeder. Daha sonra da bu öğrendiklerini günlük hayatında nerelerde kullanabilir tarzında sorgulamalarla bir başka ürünü kendisinin çıkarması beklenir. Bir etkinlikten sonra hemen bir diğerine geçmek bizim için problem olmaz fakat öğrenci anlama noktasında sıkıntı yaşayabilir. Bunun için iki veya üç etkinlik ile aynı konu üzerine odaklanmalı, ondan sonra diğer etkinliğe geçilebilir.*
>
> *[FC_INT-1]: I liked the activities. In general, the activities were good, but maybe different topics could be covered. For example,*

among the subjects the ones that students mostly get stuck in understanding could be preferred to be covered in the activities. At the thermometer activity, the students do not need such a thing. It is better to use activities to explain the subjects that are difficult to understand and require abstract thinking.

[FC_INT-1]: Ben etkinlikleri beğendim. Genel anlamda etkinlikler güzeldi ama belki birazcık daha farklı konulara değinilebilirdi. Mesela konular içerisine baktığımız zaman çocukların en çok yapmakta zorlandığı alanlar tercih edilebilirdi. Termometre etkinliğinde çocukların böyle bir şeye ihtiyacı yok. Anlaşılması zor, soyut düşünme gereken konular etkinlikler kullanılarak birazcık daha somutlaştırılabilirse daha iyi olur.

Safety precautions

One of the teachers interviewed in the first camp stated that it would be better to take safety precautions in case of any accidents and possible injuries that could be caused by the use of sharp tools like a needle, scissors, craft knife, cutter knife, etc. The same view was reflected in teachers' responses to open-ended questions. One teacher in the first camp stated in the group open-ended questions that the use of needle could be dangerous for students. Students can be informed and trained in advance about how to use activity tools and materials safety to forestall probable accidents and injuries.

[FC_INT-6]: Using needle may be a trouble because the needle may stab into the hand. One needs to be careful about it.

[FC_INT-6]: İğne kullanımı belki sıkıntı olabilir çünkü iğnenin ele batma tehlikesi olabilir. O konuda dikkatli olmak gerekiyor.

[FC_GR_OE-1]: The presence of needle and thread can be dangerous for students.

[FC_GR_OE-1]: İğne ve ipliğin olması çocuklar için tehlikeli olabilir

The acquisition of prerequisite knowledge and skills

The study results and observations from both camps showed that science teachers were deprived of both crafting and sewing skills and unfamiliar with wearable e-textile technologies. Most of the teachers' responses to interview and open-ended questions showed that teachers or students should come to the camp with the acquisition of skills and knowledge about crafting, sewing, and wearable e-textile technologies. In other words, some prerequisite knowledge and skills must be acquired before engaging in STEAM activities. Specifically, four of the teachers in the first camp expressed in the interviews that crafting and sewing practices should be made through extra activities. Similarly, one of the teachers in the first camp and three of the teachers in the second camp stated in group open-ended questions that camp participants should have been trained or educated about crafting and sewing in advance. One of the teachers also added that students could make crafting and sewing practices through extracurricular activities in technology and design course or science applications courses at the school.

> *[FC_GR_OE-1]: More information can be given about sewing at the beginning of the camp because it took a little more time to envision sewing in our minds.*
>
> *[FC_GR_OE-1]: Etkinlik başında dikiş ile ilgili daha çok bilgi verilebilir çünkü dikiş dikme olayını kafamızda canlandırmak biraz fazla vakit aldı.*
>
> *[SC_GR_OE-3]: A limited amount of information was given about the art section. Further information on art can be given.*
>
> *[SC_GR_OE-3]: Sanat kısmında bilgilendirme eksikti. Sanat ile ilgili daha fazla bilgilendirme yapilabilir.*

As to wearable e-textile technologies, one of the teachers in both the first and second camps stated in the interviews that the necessary introductory information about wearable e-textile technologies must be given before the camp. Similarly, four of the teachers in the first camp and two of the teachers in the second camp indicated in group open-ended questions that wearable e-textile technologies to be used in the activities should be introduced, such as how they function, how properly they are connected, etc. Additionally, one of the teachers in the first camp proposed the same idea about wearable e-textile technologies in post-open-ended questions. As could be observed above, many teachers who were in favor of receiving training practices on sewing, crafting, and wearable e-textile technologies were from the first camp. Because, in the second camp, science teachers were supported wit with more introductory information about sewing and wearable e-textile technologies at the outset of each activity.

> *[FC_INT-1]: The camp could be started by introducing Lilypad, sensors, and neopixels one by one. So, it would be better to use them. During the demonstration, if it is being told that sewing thread in a wrong way causes short circuiting, students may conclude that we need to be careful about that. After showing students a Lilypad, they could be told that this is a piece of circuit used in wearable technologies and you need to stitch sew tabs, marked (+) and (+), in order to connect circuit pieces.*
>
> *[FC_INT-1]: Kamp Lilypad, sensör ve neopixellerin ne işe yaradığı tek tek tanıtılıp öyle başlanılabilirdi. Böylelikle bunları kullanma daha iyi olurdu. Tanıtım sırasında, bu böyle yapılsın, ipleri dikerken böyle yaparsanız kısa devre olur vs. denilirse o zaman çocuklar buna dikkat etmeliyiz sonucunu çıkarabilir. Lilypad getirip, çocuklara bakın bu giyilebilir teknolojilerde kullanılabilen bir parça, bunu dikerken artıyı artıya dikmelisiniz denilmeli.*
>
> *[FC_POST_OE-9]: Before starting the camp, giving information about the sensors would open our horizons.*
>
> *[FC_POST_OE-9]: Kampa başlamadan önce özellikle sensörler ile ilgili bilgi verilmesi ufkumuzu açardı.*
>
> *[FC_GR_OE-7]: Informative explanations given about sensors and coding can be increased.*
>
> *[FC_GR_OE-7]: Sensörler ve kodlama ile ilgili bilgilendirici açıklamalar artırılabilir.*

What teachers recommended was that teachers or students should at first be informed about wearable e-textile technologies and then trained how to sew them with conductive thread and finally be allowed to engage in crafting a STEAM project design.

Adjusting the degree of difficulty and elaboration in the activity content

The science teacher expressed that there might be some situations in which it would be kind of necessary to make some adjustments to the degree of difficulty and elaboration in STEAM activity contents. Three of the teachers in the first camp and two of the teachers in the second camp expressed in the interviews that the current STEAM activities were well-explained and straightforward. However, if teachers were going to apply these hands-on activities in the school, their contents should be geared specifically to the needs of students with different grades, characteristics, age, and readiness levels. In summary, teachers suggested that it would be better to simplify the activity content for students with low readiness levels, match the difficulty level of activities to the students' capabilities, and calibrate the level of activities from easy to difficult in the camp.

> *[FC_INT-1]: I can say that the activity content can be elaborated a little more if the individual differences of the students are considered. Normally the content of the current activities is sufficient for an average student, but the steps followed in the activity should be more explanatory because some students have problems in understanding. Like a prescription for use, the activities can include step-by-step instructions.*

> *[FC_INT-1]: Yani şöyle diyebilirim. Çocukların bireysel farklılıklarını göz önünde bulunduracak olursak, biraz daha detaya girilebilir. Normalde orta seviyedeki bir öğrenci için yeterli ancak bazı çocuklar anlama problemi çektiği için adımlar biraz daha açıklayıcı olmalı. Mesela kullanım talimatları gibi adım adım ilerletecek şekilde olabilir.*

> *[SC_INT-2]: The content of the activity should of course be changed according to the age group. The activity content used for the teachers cannot be used for the students. There are even cases where we cannot use the same activity documents for two different classes. As I said, boys and girls also fill in the activity paper differently. Therefore, I think that the activities should be planned as much as possible for the student age group and differences.*

> *[SC_INT-2]: Etkinliğin içeriği yaş grubuna göre tabi ki değiştirilmeli. Öğretmenler için kullanılan etkinlik içeriklerini öğreciler için direkt kullanamayız. Hatta bir sınıfta kullandığımız etkinlik dökümanlarını öbür sınıfta kullanamadığımız durumlar*

bile oluyor. Dediğim gibi erkek ve kız çocukları da etkinlik kâğıdını farklı dolduruluyor. O nedenle etkinliklerin olabildiğince öğrenci yaş grubuna ve farklılıklarına uygun planlanması gerektiğini düşünüyorum.

Adjusting the level of autonomy and freedom in project design

Different from traditional science activities, the STEAM activities require to come up with the best solution to the problem by leveraging the limited number of materials available in the environment. Two teachers from the second camp expressed in the interviews that teachers or students should have more autonomy and freedom in their design, especially the number of wearable e-textile technologies. However, to a certain point, some limitations have to be imposed on materials usage; otherwise, it would go into an endless loop. Additionally, giving considerable autonomy and freedom in project design is just against the prepositions and arguments concerning the STEAM approach.

> *[SC_INT-1]: In my personal opinion, actually, it is nice to conduct activities as prescribed in the activity form, but I am in favor of giving participants autonomy during the design process. Let the student decide himself what to stick with during the activity. For example, if a student wants to paste a material first, let him or her do it. The shape and design of product should be controlled by its own designer. It is not right to say, "go in order" or "do this first". Of course, it is nice to go in accordance with a plan, but I think this should not be done in the first stage. There must be a way to project our imagination to the outside.*

> *[SC_INT-1]: Ben kişisel görüşümü söylüyorum. Aslında etkinliklerin belirtildiği şekilde yapılması güzel ama ben tasarım sürecinin serbest bırakılması taraftarıyım. Öğrenci bir şeyi ne ile yapıştırması gerektiğine kendisi karar versin. Örneğin bir malzemeyi önce yapıştırmak istiyorsa önce yapıştırsın. Ürün onu tasarlayanın hareket becerisine göre şekillenmeli ve serbest bırakmalıyız. "Sıraya göre git" yada "önce bunu yap" denmesi doğru değil. Tabi ki planlı olmak güzel ama bence ilk aşamada bu yapılmamalı. Artık hayal gücümüzü dışarıya yansıtmanın bir yolu olmalı.*

[SC_INT-3]: There must be scenarios, but they must be open-ended. For example, the scenario tells me that you must use four LEDs, but I want to use five. Or, for example, we built a lighthouse, the lighthouse has a light sensor at the bottom, it has a neopixel on it, and I want to use a buzzer next to this light sensor. The participants should be released a little more here. When the project design is made according to the given material, it looks as if there is a restriction on the design.

[SC_INT-3]: Senaryolar olmalı ama senaryoların ucu açık bırakılmalı. Örneğin senaryo bana diyor ki 4 tane led kulan fakat ben 5 tane kullanmak istiyorum gibi. Ya da mesela bir deniz feneri yaptık, deniz fenerinde altta bir ışık sensörü var, üzerinde neopixel var, ben bu ışık sensörünün yanında buzzer kullanmak istiyorum. Burada katılımcılar biraz daha serbest bırakılmalı. Verilen malzemeye göre yapıldığı zaman sanki kısıtlama yapılmış gibi oluyor.

4.5.1.3.3.3 Arranging and adjusting physical space

It is crucial to arrange physical STEAM activity space in a way that can make groups move and walk around comfortably while working on their designs and support interactions and collaborations within and between the groups. In the pilot study, groups of teachers made their project design in a school classroom using classroom chairs and tables, which were relatively small to accommodate a group of more than two teachers. The groups in the pilot study were observed to have great difficulties in keeping working on the project design. In their responses to open-ended questions, they also complained that the physical space or environment was unsuitable for hands-on activities and not equipped with desirable conditions. For that reason, the first and the second camp took place at a large venue with different physical conditions. The study results showed that teachers were utterly content with the camp environment, but some of the teachers made a few suggestions for the arrangement of activity space in the school. Two of the teachers interviewed in the first camp proposed that the classroom or activity environment should have a u-shaped layout with a large round table for materials and tools and medium-size immovable round tables for group work.

[SC_INT-3]: There may be round table for group work. There may be a U-shape arrangement that can support working together because it is necessary to producing different ideas. In short, these class designs can be considered.

[SC_INT-3]: Grup çalışmaları için yuvarlak masa olabilir. Birlikte çalışmayı sağlayabilecek U düzeni olabilir. Çünkü farklı fikirlerin oluşması için bu gerekli. Kısaca, bu sınıf tasarımları düşünülebilir.

[SC_INT-4]: The layout in the camp was a bit confused. The same things will be in schools, or maybe even worse. Our table at the camp was a bit small and narrow. For example, the activity table should be wider, and the materials should be placed on tables that do not move.

[SC_INT-4]: Kamptaki düzen biraz karışmıştı. Okullarda da aynı şey olacak hatta belki daha beteri olacak. Kamptaki masamız biraz küçük ve dardı. Mesela etkinlik masası daha geniş olmalı ve malzemeler hareket etmeyen maslara konulması gerekiyor.

In addition to the suggestions above, a STEAM camp should be applied and implemented in an environment with adequate temperature, light, and airy conditions. Additionally, the physical space of the camp should be equipped with sufficient tables and chairs in different sizes and dimensions.

The diversity of materials

In both camps, there were a variety of wearable e-textile technologies and designs and crafting materials and tools at teachers' disposal. Specifically, three of the teachers in the first camp and one of the teachers in the second camp expressed in the interviews that if a STEAM camp was to be implemented for teachers or students in the school or somewhere else, it should be equipped with more diverse and abundance of materials and tools.

[FC_INT-1]: If you want to do an activity like this, you should have more activity materials. If you want creativity, you should have more materials. You cannot do works with limited materials, and you cannot show your creativity too much. Let us say you are designing a very different product, you want to create a design that

involves a smell sensor, but there is no smell sensor. This limits your imagination.

[FC_INT-1]: Yani şöyle eğer böyle bir etkinlik yapmak istiyorsanız malzemeleriniz daha fazla olmalı. Yaratıcılık istiyorsanız, malzemeleriniz daha fazla olmalı. Kısıtlı malzemeyle iş yapamazsınız ve yaratıcılığınızı çok fazla gösteremezsiniz. Diyelim ki çok farklı bir ürün tasarlıyorsunuz, atıyorum koku alma sensörüyle ilgili bir şey yapmak istiyorsunuz ama ortada koku alma sensörü yok. Bu sizin hayal gücünüzü kısıtlamış oluyor.

[SC_INT-3]: I have many thoughts going on in my head about the project design. In order to put those thoughts into action, it is necessary to create the design pattern of the project and use the appropriate materials for that pattern. A lot of materials might be needed for that design. Therefore, a variety of materials must be available. If you have limited materials, the works you are going to do also become limited.

[SC_INT-3]: Proje hakkında kafamda birçok düşünce geçiyor. Onları hayata geçirebilmek için de projenin tasarım kalıbını oluşturmak ve o kalıba uygun malzemeyi kullanmak gerekiyor. Onun için çok malzeme gerekiyor olabilir. Bu yüzden malzeme çeşitliliğinin fazla olması gerekiyor. Elinizde kısıtlı malzemeler varsa, yapacağınız işlerde kısıtlı oluyor.

Similar suggestions were reflected in teachers' responses to group open-ended questions. For example, three of the teachers in the first camp suggested that a thick but soft fabric should be used instead of thin and hard ones because it was quite challenging to sew into both thin and hard clothes. They also added that there should be fabric sheets with ready-made felt shapes and templates so that students did not spend time on cutting. In addition to that, equipping a camp environment with a wide variety of cutting dies and molds in different shapes and sizes can help students and teachers make better designs in terms of crafting.

[FC_GR_OE-5]: Prefabricated felt molds can be used as material instead of felt as whole. For example, if we had geometric molds, we could cut the felts more easily. This provides an advantage in terms of time. In other words, the designs can be done in a short time.

[FC_GR_OE-5]: Malzeme olarak keçe yerine hazır kalıplar verilebilir. Örneğin geometrik kalıplar elimizde olsaydı keçeleri

daha rahat kesebilirdik. Bu süre açısından da avantaj sağlar. Yani tasarımlar kısa sürede yapılabilir.

[FC_GR_OE-7]: The felt fabrics used in the activities could have been chosen a little thicker.

[FC_GR_OE-7]: Etkinliklerde kullanılan kumaşlar biraz daha kalın seçilebilirdi.

Besides, one of the teachers in the first camp and five of the teachers in the second camp stated in post-open-ended questions that there should have been a vast and diverse number of materials available in the camp. Teachers explained that the amount and diversity of wearable e-textile technologies should be increased, such as sensors, LEDs, Arduino Lilypad, etc.

[SC_POST_OE-4]: In the camp, problems took place due to repeated use of the activity materials.

[SC_POST_OE-4]: Kampta etkinlik malzemeleri tekrar tekrar kullanıldığı için problem oluyordu.

[SC_POST_OE-7]: If there had been more sewable electronics like sensors, LEDs, Lilypads, and so on, more original desingns might have been produced.

[SC_POST_OE-7]: Sensörler, ledler, Lilypad'ler vs sayica fazla olsaydı yapılan etkinliklerde daha özgün seyler çıkabilirdi.

However, bringing all these staff and materials together requires lots of effort and, most importantly, adequate school budget or financial support, which seems to be one of the main barriers to the implementation of STEAM activities in the schools. It appears that teachers or schools may not afford to buy all these materials alone by themselves unless they take a certain amount of financial support and funding through projects from the Scientific and Technological Research Council of Turkey.

4.5.1.3.3.4 Fostering collaboration and interaction within and between groups

One of the important features of the STEAM activities is to enable people (teachers or students to work) to work together to make innovative and creative project design. In both camps, as well as in the pilot study, the groups of two or three teachers worked together on their project design collaboratively and interactively. Science teachers remarked upon some strategies that could be applied to foster collaboration within and between groups. Five of the teachers in the first camp and one of the teachers in the second camp expressed in the interviews that to increase collaboration and participants within and between groups, group members should be changed among themselves.

> *[FC_INT-2]: If you want to increase the exchange of ideas, you can change the cluster of participants. The topics remain the same, but let us think of four people, Ali, Veli, Ahmet and Ayşe. When you make them groups of two in four different ways, you can create groups in which each can work together interactively. This allows you to exchange more ideas and get more diversity. After each activity you need to change the group members. For this, the participants can be randomly assigned to the groups.*
>
> *[FC_INT-2]: Eğer fikir alışverişinin çok olmasını istiyorsanız küme değişikliği yapabilirsiniz. Konular aynı kalır ama mesela dört kişi düşünelim, Ali, Veli, Ahmet ve Ayşe. Bunları dört farklı şekilde ikişerli grup yaptığınız zaman her birinin birlikte etkileşimli gruplar yapabilirsiniz. Böylelikle fikir alışverişi daha fazla olur ve daha çok çeşitlilik elde edebilirsiniz. Her etkinlikten sonra grup üyelerini değiştirmek gerekiyor. Bunun için üyeleri gruplara rastgele olarak atamak olabilir.*

One teacher from the first camp suggested that each student in the group should be assigned a different role like a fashion designer, engineer, scientist, etc. In this way, each team member would work and act in line with the assigned role and accordingly carry out the design tasks associated with that role.

> *[FC_INT-5]: There may be task-sharing within the group. For example, a student can take on the role of an engineer in one of the events, one can take on the role of designer, fashion designer, and another can play the role of mathematics. For example, they can work online. Each student can collect data related to his/her subject area, collect information and then share it. Students can exchange information among themselves. You can also look at the event from that direction.*
>
> *[FC_INT-5]: Grup içerisinde görev paylaşımı olabilir. Mesela bir öğrenci etkinliğin birinde mühendis rolünü üstlenebilir, bir tanesi tasarımcı, moda tasarımcısı rolünü üstlenebilir, diğer bir öğrenci matematik rolünü olabilir. Bunlar mesela çevrim içi çalışırlar. Her bir öğrenci kendi konu alanı ile ilgili veriyi toplar, bilgiyi*

toplar ve sonra paylaşır. Çocuklar kendi arasında bilgi alışverişi yapabilir. O yönden de bakılabilir etkinliğe.

The same view was reflected in teachers' responses to open-ended questions. Two of the teachers in both the first and the second camp stated in post open-ended questions that changing group members among themselves would spark interaction and collaboration within and between groups. Additionally, two of the teachers in the second camp reported in group open-ended questions that group members must change for every activity. As a result, this strategy can actively encourage collaboration and the exchange of different skill sets, experiences, and knowledge across multiple subjects by driving each member to share his/her experiences with new group members. In this respect, collaborative learning with STEAM activities can bring a diverse range of benefits to the students.

[FC_POST_OE-2]: Groups of two teachers were large enough. Group mates could have been changed.

[FC_POST_OE-2]: İki kişilik gruplar yeterli büyüklükteydi. Grup arkadaşları değiştirilebilirdi.

[SC_POST_OE-13]: Being in groups made things a little easier but more homogeneous groups could be formed if a group would have different members in each day.

[SC_POST_OE-13]: Grup olması işleri biraz kolaylaştırdı ama her gün farklı kişiler çalışırsa daha homojen gruplar kurulabilirdi.

The group formation methods

In the STEAM activities, a group can be formed in a variety of ways depending on the purpose or objectives aiming to achieve at the end. However, a group that is created based on wrong strategies may cause group members to experience conflicts and failures during the project design process. The forming of the group is covered under two parts: group formation strategies and group size. For the first part, strategies, two teachers from the first camp, and four teachers from the second camp suggested in the interviews that groups shouldn't be formed arbitrarily. In other words, there should be intervention while forming groups for a STEAM activity.

One of the teachers in the first camp and three of the teachers in the second camp expressed in the interviews that a group should be heterogeneous, including at least one female and male participant. The same suggestion was reflected in teachers' responses to open-ended questions. Two of the teachers in the second camp stated in post-open-ended questions that the groups should be composed of male and female participants.

> *[FC_INT-3]: The number of participants in a group must be at least three; two men and one woman. Men need a skill that can make their one-sided perspectives colorful and transform into aesthetics. That skill exists in women. I think like this, at least. The formation of a mixed group in terms of gender increases creation of both ideas and aesthetics.*
>
> *[FC_INT-3]: Gruptaki kişi sayısı en az üç olmalı; iki erkek ve bir bayan. Erkeklerin düz bakışını daha renklendirecek ve estetiğe dönüştürebilecek bir beceriye ihtiyaç var. O beceri da kadınlarda var. Ben böyle olduğunu düşünüyorum. Cinsiyet bakımından karma bir grubun oluşması hem fikirleri hem de estetiği artırır.*
>
> *[SC_INT-2]: There should be girls and boys in the groups because when we look at gender difference in brain, we see that men look a little more straightforward while women have a multi-faceted and high perception. Men may develop their own perceptions alongside women. At the same time, different sexes must be able to come together and do works in the same environment in a tolerant way. After all, men and women are people who live together in this society. Therefore, under the supervision of teachers, boys and girls should be in the same group and work together.*
>
> *[SC_INT-2]: Gruplarda kız ve erkek olmalı çünkü beyin olarak incelediğimiz zaman erkeklerin biraz daha düz mantıkla baktığını görüyoruz, bayanların ise çok yönlü ve yüksek algıları var. Erkeklerler belki bayanların yanında kendi algılarını da geliştirebilir. Aynı zamanda farklı cinsiyetlerin yan yana gelip, birbirleriyle hoş görülü bir şekilde aynı ortamda iş yapabilme yeteneğine sahip olması lazım. Sonuçta erkek ve kadın bireyler bu toplumun içerisinde birlikte yaşayan insanlar. O nedenle öğretmen gözetiminde erkek ve kız öğrenci aynı grupta olmalı ve birlikte çalışmalı.*
>
> *[SC_POST_OE-9]: For more ideas and aesthetics, male participants should be in the same groups together with female participants.*

[SC_POST_OE-9]: Daha çok fikir ve estetik aşaması için bayan katılımcılar ile birlikte erkek katılımcıların aynı gruplarda olmalı.

In the STEAM activities, the right decisions on group size are as important as the right strategies for group formation. According to science teachers, group size could be either small or large. In their perspectives, in a STEAM activity, the upper and lower limit of a group size should be at most three and at least two participants, respectively. All six of the teachers in the first camp and two of the teachers in the second camp indicated in the interviews that group size shouldn't be larger than three members. The same view was highlighted in teachers' responses to open-ended questions. For instance, two of the teachers in the first camp reported in group open-ended questions that two members could be an ideal group size for STEAM activities. According to teachers, two members were a perfect number per group, but on some occasions, this number could be increased to three. As a result, the majority of teachers reported that the number of members per group shouldn't be larger than two or at most three; because, as the group size increased, the contribution and engagement shared by each student in the group decreased.

[FC_INT-4]: I think groups should not be too crowded. The number of people in the group should not exceed three. These activities are not difficult, suiting to the learning level of the student. When the number of students exceeds three in a group, some students of the group may sit idly or some students may say "what can I do?"

[FC_INT-4]: Bence grupların çok kalabalık olmaması gerekiyor. Gruptaki kişi sayısı üçü geçmemesi lazım. Bu etkinlikler zor değil, öğrencinin öğrenebileceği düzeyde. Kişi sayısı üçü geçtiği zaman bazı öğrenciler boş boş oturabilir ya da bazı öğrenciler ben ne yapabilirim diyebilir.

[SC_INT-3]: Doing activities in groups of two will be nice for students to learn group work because the child would not learn to share when he does the activities alone. In groups of two people, there is an exchange of ideas. Students share something together and learn to make work division. This in turn contributes to their personalities.

[SC_INT-3]: İki kişilik gruplar halinde yapılması çocukların grup çalışmasını öğrenmesi açısından güzel olur çünkü çocuk tek

başına yaptığı zaman paylaşmayı öğrenmiyor. İki kişilik gruplarda da bir fikir alışverişi oluyor, çoçuklar birlikte bir şey paylaşıyorlar, iş bölümü yapmayı öğreniyorlar. Kendi kişiliklerine de katısı oluyor.

[SC_POST_OE-9]: For activities, a group with two students are ideal. Some students may not work if the number is high. Exchanging ideas with other groups enabled collaborative work.

[SC_POST_OE-9]: İkişer kişilik gruplar gayet ideal. Sayı fazla olması durumunda bazı kişiler çalışmalayabilir. Diğer gruplar ile fikir alışverişi işbirlikli çalışmayı sağladı.

However, a small number of teachers reported that the members of a group might be larger than three participants. One of the teachers in both the first and the second camp stated in the interviews that it would be better to increase the group size from two or three to four or even five members. They thought that larger groups compared to small group sizes supported more learning gains, and less amount of time lasted for each activity.

[FC_INT-6]: It would be better to increase the number of people in groups. Cooperative learning with two people and four people is different. Group work with four people will produce different and more creative ideas.

[FC_INT-6]: Gruplardaki kişi sayısı artarsa daha iyi olur. İki kişi ve dört kişi ile yapılan iş birlikli öğrenme farklı olur. Dört kişiyle grup çalışması daha farklı daha yaratıcı fikirler ortaya çıkaracaktır.

Related to whether the STEAM activities should be implemented individually or in groups, most teachers reported that group working suited more to STEAM activities. That is seven of the teachers in the first camp and ten of the teachers in the second camp mentioned in post-open-ended questions that STEAM activities should be implemented in groups rather than by the individual.

[FC_POST_OE-3]: The activities should definitely be implemented in groups. Brainstorming and working collaboratively reveal creative knowledge.

[FC_POST_OE-3]: Etkinlikler kesinlikle grup halinde olmali. Beyin fırtınası ve işbirliği içerisinde çalışma yaratıcı bilgileri ortaya çıkartıyor.

[SC_POST_OE-11]: It was a process supporting group working, communication and collaboration skills. Therefore, it is an activity that is required to be used in problem-based applications.

[SC_POST_OE-11]: Grup çalışması, iletişim ve işbirliğini destekleyen bir süreçti. Bu nedenle problem tabanlı uygulamalarda kullanımı gerekli olan bir etkinlik.

Although the ideal group size for maintaining effective group dynamics is believed to be two to four students, that doesn't seem to be possible in schools with crowded classrooms and inadequate facilities. In overcrowded classes, any reduction in group size will automatically bring an increase to the number of groups, and, in turn, impose additional coordination and management of the project design upon teachers.

4.5.1.3.3.5 Setting the amount of activity time

It is vital to allocate a fair amount of time required to make a STEAM project design. Both first and second camp involved seven STEAM activities which were varied to difficulty level, the sort of e-textile technologies used, and the type of project design required. Therefore, the optimum amount of time allotted to each STEAM activity was determined after the experiences from the pilot study and the mentioned variations between activities were taken into consideration. The observations from both camps showed that while some groups completed the project design within the specified time, the others couldn't. There might, of course, be many reasons why some groups were inferior to the others in time performance on project design. Analysis of teachers' responses to the interviews and open-ended questions showed that the majority of the teachers preferred to have more time for each STEAM activity. One of the teachers in both the first and second camps reported in the interviews that the amount of time allocated for STEAM activities should be increased.

[FC_INT-3]: Well, the length of the activity times could have been extended a bit longer. We could perhaps make more good designs when the time was a bit longer. The lack of time was a bit troublesome for us.

[FC_INT-3]: Yani etkinlik süreleri biraz daha geniş olabilirdi. Süre birazcık daha geniş olduğunda belki daha güzel tasarımlar yapabilirdik. Zamanın yetmemesi bizim açımızdan birazcık sıkıntılı oldu.

[SC_INT-3]: I think we should only make some changes in terms of time. For a middle school student, the given time may be insufficient. At least it would be better to give some time to middle school students before the activity because time was the part we struggled most. In our activities, we need to perform implemention process within the specified time period. Within the given time, even for us, it was difficult to finish the project design, so this will be worse for a middle school student.

[SC_INT-3]: Sadece zaman açısından bence biraz değişiklik yapılmalı. Verilen süre bir ortaokul öğrencisi için az gelebilir. En azından etkinlik öncesinde süre verilmesi ortaokul öğrencileri için daha iyi olur. Çünkü bizim en çok zorlandığımız kısım zamandı. Yaptığımız etkinliklerde hem süreyi iyi kullanabilmek hem de uygulamaya geçebilmek gerekiyor. Bu süre zarfında bizi bile zorladığına göre bir ortaokul öğrencisini daha çok zorlar.

Besides, two of the teachers in the first camp and four of the teachers in the second camp stated in group-open-ended questions that increasing the activity time would allow groups to make a rigorous project design, carefully crafting the STEAM design and giving a lot of attention to details. Also, three of the teachers in both the first and the second camp reported in post-open-ended questions that the camp time should be kept longer. Consequently, a prevalent suggestion among teachers was to devote more time to STEAM activities due to lots of sewing and crafting efforts required during the design process.

[FC_POST_OE-5]: It could be better to extend the duration of the camp. Keeping us continuously engaged during the camp process was very important for our development

[FC_POST_OE-5]: Etkinlik sürelerini uzatmak daha iyi olabilirdi. Bizleri sürekli sürecin içinde tutmanız gelişim için çok önemliydi.

[SC_POST_OE-4]: The duration of the camp could have been longer. These activities can be done as a Tubitak project. The camp can last longer and have a wider content.

> *[SC_POST_OE-4]: Kamp suresi daha uzun olabilirdi. Bu etkinlikler bir Tubitak projesi olarak yapılabilir. Kamp daha uzun sureli ve içeriği daha geniş olabilir.*
>
> *[SC_GR_OE-2]: Sufficient time should be allocated for the project design. More time should be given for the implementation of the project design.*
>
> *[SC_GR_OE-2]: Tasarım için yeterli zaman ayrılmalı. Tasarım uygulaması için fazla zaman verilmeli.*

Besides, teachers were aware of the fact that students' design and crafting capabilities are not as good as teachers. That's why it is highly likely that the time that was inadequate for teachers would not satisfy the needs of students as well. As a result, teachers suggested that if these hands-on activities were going to be applied by students, the best decision would be to allocate more time than it took for each activity in the camp

4.5.1.4 Design principles for the activities' implementation in school

In the camp, it is crucial to scaffold the teachers' works and efforts in their project design process. At the beginning of the camp, especially in the first two activities, groups of teachers tend to seek more assisting and guidance than in the activities followed. Therefore, there should be an adequate number of facilitators to meet teachers helping demands at the earlier phases of the camp. However, this study suggests that the degree of support facilitators gave to the groups could be adjusted as the camp progress. In times, it could be a better strategy to decrease the degree of support and help given during the camp since teachers might get used to asking for help even for the trivial things or the things they can easily overcome with a little effort.

Additionally, more support could be harmful rather than beneficial after teachers become familiar with the camp materials and aware of what they are supposed to do in the activities. For a STEAM camp with twenty groups of two teachers, there should be at least five facilitators. One of the facilitators must be knowledgeable about wearable e-textile technologies. Also, one facilitator should know circuitry and Arduino coding.

The circuit diagram should be attached to the activity form not only for students but also for teachers as well because teachers or students who don't have relevant activity experiences on Arduino circuitry may not be able to make the right connections across pieces of the project circuit. However, for the simple activities that connect an LED to the Lilypad battery, the circuit diagram might be excluded or omitted from the activity content.

Arranging the activity content in the following sequence would be useful. First and first, it should be noted that it is vital that the content of design thinking stages are in parallel with the content of a STEAM activity. Second, at the beginning of each activity, there should be a piece of elaborative introductory information about the activity materials and the way activity is conducted. Third, if Arduino coding is to be taught in the camp, that shouldn't be isolated from the activity itself. For example, once the groups finish their design, they could be given time to write their project code. After that time, irrespective of whether they are able to write the code by themselves or not, they could proceed to write the code in collaboration with the facilitators. Forth, there should be a presentation session at the end of each activity where groups present their projects. Fifth, the camp could be followed by an exhibition of groups STEAM project designs. The exhibition would allow teachers or students to showcase their abilities and skills in public, which could drive them to attentively and passionately engage in the activity design process in the first place. Moreover, after the camp, it might be better to ask each group to prepare a lesson plan based on the knowledge and experiences they have acquired in the camp.

An activity scenario should be attached to each STEAM activity because it gives each group a path to follow or a goal to achieve at the end. While forming and writing an activity scenario for a STEAM activity, it is crucial to make sure that it has some essential characteristics. For instance, an activity scenario shouldn't be too long and full of unnecessary details and redundant words. For the students, the activity scenario should be geared towards some student-related factors like grades, interests, and life experiences. In other words, it would be better to take the student's current life, surroundings, interests, and district into consideration when forming an activity scenario.

The overall objectives or goals targeted to achieve in the camp should be consistent with the objectives in the existing educational program or curriculum. Moreover, it is suggested that the learning objectives in STEAM activities should be geared specifically to the needs of students in multiple subjects. Also, the STEAM connections should be apparent and transparent so that teachers or students could feel the connections while making a transition from one subject to another. Furthermore, STEAM activities should be designed to focus on the learning of abstract concepts instead of facts and concrete ones.

Some instructional practices could be used to stimulate the participants' creativity and art skills. For instance, the problems posed in the activity scenario should be relevant to the real-life issues or matters that are prevailing and need a solution in the society or the surroundings. Furthermore, STEAM activities might appeal to females' interests more than male students. Therefore, a STEAM camp could be used to drive female students' attention and participation in the STEAM subjects. Moreover, there should be constraints of materials in the camp, especially e-textile technologies. The use of more e-textile technologies could make the project design complicated and difficult to handle and, in turn, discourage groups from using their creative skills. As for design and crafting materials, groups should be allowed to benefit from as many materials as they want as long as they don't waste it. Besides, showing groups some exemplary design projects in advance could inspire them to demonstrate their art skills in their project. Also, groups are likely to borrow some ideas from exemplary design projects and develop them in a better and more efficient way. For students, field trips could be organized to stimulate their art skills.

Giving a degree of autonomy and control participants have over their project design can increase their art skills. The design of STEAM activities in the camp could be structured and unstructured depending on the participants' knowledge level and their familiarity with hands-on activities, including wearable e-textile technologies. It is better to apply structured activities when participants have less or no experience of STEAM-like activities. On the other hand, if participants have previous experiences in similar hands-on activities, it could be more beneficial to use unstructured activities.

During the camp, unfortunate or unexpected accidents may happen and some of the tools in the camp could lead to injuries. To prevent such incidents from happening, some safety precautions should be taken in advance. For instance, participants could be informed to be careful while working with sharp tools such as a needle, scissors, craft knife, cutter knife, etc. Also, there must be a first aid kit in the camp place so that those who are injured during the camp could be treated immediately.

In advance of the camp, the participants who are lack of skills in both crafting and sewing could be trained through additional activities or tasks. It could be beneficial to inform them about wearable e-textile technologies such as how they function and how they are connected through sewing.

The degree of difficulty and elaboration in the content of STEAM activities should be adjusted to the participants' abilities and comprehension levels. The writing style and the words chosen for the activity content must be geared specifically to the students' characteristics like grade.

The physical space of the camp should be arranged in a way that would allow groups to move and walk around comfortably while working on their designs and support interactions and collaborations within and between the groups. Besides, in the camp environment, there should be at least one large round table to put materials on the top. Moreover, each group should have a medium-size round table for the group work.

The STEAM activities should be made in groups rather than individually. In order to spark collaboration and participation within and between groups, group members could be switched for each activity. Moreover, each of the group members could be assigned a different role as a designer, technologist, coder, etc. While forming a group, one of the group members must be female. In other words, a group should be composed of both sexes, female and male. Furthermore, the total number of participants in a group shouldn't be larger than three and smaller than two.

A STEAM camp for teachers could be arranged as one or two-hours study sections with a five-minute break. One-hour break would be enough for teachers to have lunch. The lunch hour could be given after two or three sections depending on the difficulty of the activity. The physical conditions should also be taken into account when designing a STEAM camp. The camp could be conducted in either summer or winter times. In any case, there should be an air-conditioning in the cam place.

The time it takes to complete hands-on activities in the camp relies largely on the participant type. For the teachers, for example, the existing amount of time allocated for each STEAM activity could be adequate. However, for the students, it is advised to allocate more time for each activity.

4.5.1.5 Assessment of performance and learning in STEAM activities

In the STEAM context, assessment is considered to involve the process of drawing different types of data from the e-textile project design process using various data sources. This section covers teachers' suggestions for the assessment of STEAM learning. There are four parts described below in this section, which are the scarcity of measurement tools, assessment tools to use, key aspects to focus and address, and the way of developing assessment tools.

4.5.1.5.1 The scarcity of measurement tools

The big hurdle facing arts-integrated hands-on activities along with the supply of e-textile materials would undoubtedly be assessing STEAM learning and proficiency (or learning) across multiple content areas because learning or educational outcomes of each STEAM project may come out in many different forms that require using authentic assessment tools. However, as stated by a teacher interviewed in the second camp, there had been a scarcity of measurement tools to assess performance and learning in STEAM activities.

> *[SC_INT-4]: Here, you definitely need to look at the design process. Using a multiple-choice tes is wrongt. I think it would be right to use rubrics for measuring STEAM learning. In other words, new measurement tools related to STEAM need to be developed because the measurement tools that are currently being applied are not appropriate.*
>
> *[SC_INT-4]: Burada kesinlikle tasarım sürecine bakmak gerekiyor. Çoktan seçmeli test şeklinde olmaz. Zaten bu STEAM'de rubriklerin kullanılmasının doğru olacağını düşünüyorum. Yani şuan STEAM ile ilgili yeni ölçme araçlarının geliştirilmesi gerekiyor çünkü şu anda uygulanan ölçme araçlar çok yeterli olmuyor.*

4.5.1.5.2 Assessment tools to use

Four of the teachers interviewed in both the first and second camps suggested a set of assessment tools that could be used to assess student learning outcomes in STEAM projects. Those tools, which were sorted by expression intensity of teachers, included a rubric, reflection or open-ended questions, observation, peer and self-assessment form, chart, checklist, activity diary or journal, and portfolio. Two of the teachers in both the first and the second camp reported that rubrics would be an objective assessment tool for measuring STEAM learning.

> *[FC_INT-6]: The evaluation of STEAM learning would be objective if rubric is prepared for design, drawing, sketching, introduction and presentation sections. The achievement levels of the students can be measured by giving them points according to these sections.*
>
> *[FC_INT-6]: Etkinlikleri değerlendirme sırasında tasarım, çizim, taslak çizimi, açıklama bölümü ve sunum bölümleri için rubrik*

yapılırsa objektif bir değerlendirme olabilir. Bu bölümlere göre de puan verilerek öğrencilerin başarı seviyeleri ölçülebilir.

[FC_INT-5]: The rubrics can generally be used to evaluate STEAM activities. This may be a rubric that evaluates the product or a rubric that measures how much the project design solves the problem. Other students can evaluate the project design aesthetically, or groups of students can rate the projects that have been done

[FC_INT-5]: STEAM etkinliklerinin değerlendirmesınde genel olarak rubrikler kullanılabilir. Bu bir ürün değerlendirme rubriği olabilir ya da ürünün problemi ne kadar çözdüğünü ölçen bir araç. Diğer öğrenciler tasarımı estetik olarak değerlendirilebilir ya da gruplar yapılan çalışmayı puanlayabilir.

Three of the teachers interviewed in the second camp stated that observation could be used as an assessment tool to observe and monitor students' successes, failures, mistakes, and understandings. Furthermore, one of the teachers in both the first and second camps suggested in the interviews that reflection or open-ended questions could be used to measure how students reflected their learning and understanding at the intersection of multiple subjects.

[FC_INT-5]: Again, I think there should be definitely open-ended questions. Such open-ended questions can be asked: how did you connect the LEDs when setting up the circuit, what was the benefit of parallel connection and etc. The students will answer these questions by engaging and interacting with these activities. This will both improve the student's writing skills and help him/her learn the subject.

[FC_INT-5]: Yine açık uçlu soruların kesinlikle olması gerektiğini düşünüyorum. Açık uçlu sorularda örneğin "devreyi kurarken ledleri nasıl bağladınız?" ve "paralel bağlamanın faydası ne olmuştur" gibi sorular sorulabilir. Çünkü çocuk yaptığı etkinlikle bağlantı kurarak bu soruları cevaplayacak. Bu çocuğun hem yazma becerisini geliştirecek, hem de konuyu öğrenmesini sağlayacaktır.

[SC_INT-1]: You can only oversee the performance of the students in the activity by observation. Many questions can be answered using the method of observation. In order to respond the following questions, observation is the only possible way: how did the student sew? Had he improved his ability to sew? How had he

designed? Had he used different materials in the design? and had he used materials that others did not?

[SC_INT-1]: Öğrencilerin etkinlikteki performanslarını ancak gözlemle görebilirsiniz. Örneğin, çocuk dikimi nasıl yapıyor, dikme yeteneğini geliştirebildi mi, tasarımı nasıl yaptı, tasarımda farklı malzemeler kullandı mı ve başkalarının kullanmadığı malzemeleri kullandı mı gibi sorular sadece gözlem ile anlaşılabilir.

Peer and self-assessment forms were another tool suggested by teachers. Two of the teachers interviewed in the first camp reported that STEAM learning could be measured through peer and self-assessment methods. They thought that this would enable us to measure individual and group learning at the same time.

[FC_INT-2]: STEAM learning gains can be analyzed through peer and self-assessment forms. Even we love our own product as if it is our child. Yet, there could be such problem: student may misjudge other student's project design for their own benefit. So, such forms as in-group evaluation and peer and self-evaluation can be used to measure STEAM learning. As a different kind of measurement method, for example, students could be given additional points when they draw a circuit diagram. But this only works if scores are to be given on students' performance in activity.

[FC_INT-2]: STEAM kazanımları akran ve öz değerlendirmesi formları ile incelenebilir. Biz bile kendi ürünümüzü çocuğumuz gibi seviyoruz. Şöyle bir problem de olabilir: Çocuklar kendi ürünleri için bu sefer başkalarınınkini kötüleyebilirler. Ama grup içi değerlendirme, akran ve öz değerlendirme formları kullanılabilir. Başka türlü bir ölçüm olarak belki şey olabilir; devre şeması çizerek ek puan verme olabilir, eğer puanlama yapılacaksa illa ki.

4.5.1.5.3 Key aspects to focus and address in the assessment process

The analysis of the data drawn from the assessment of performance and learning in STEAM activities can lay out some vital information on instruction and learning. For instruction, it can inform how effective the given instructional strategies are regarding involving students in STEAM projects. On the other hand, for learning, it can enlighten how successful the STEAM activities are in terms of yielding the intended STEAM learning goals. The findings showed that all of the teachers interviewed in both the first and second camps commonly referred to three aspects of STEAM activities to focus and address in the assessment of STEAM learning: process, product, and performance. According to teachers, an authentic assessment of STEAM learning should be made at the intersection of the project design process, final design product or prototype, and overall performance. These three aspects are inextricably interwoven so that one aspect can't exist without the presence of the other two aspects.

> *[FC_INT-5]: I think that measuring the learning outcomes in the activities should not be independent of the project design process, because if the design process is carried out successfully from beginning to end, the end product will also be successful. For example, the student's finger muscles may not be very well developed, and when you look at the project design, the project might meet the technical criteria but the final design may look a bit worse in terms of artistic and aesthetic. Therefore, the evaluation of the project should not be independent of the design process. Our aim in the activities is to help students get the scientific knowledge and learning gains in other disciplines as well. At this point, it is necessary to know very well what the students are doing in the design process. If the designed product complies with our criteria in general, there may not be assessments about art that may discourage students. For the evalution of the project, there could be following considerations. First, the best project designs can be selected in terms of technical manner. Second, the aesthetic aspect of project design could be evaluated. Third, project design could be evaluated with respect to creativity. At this point, it is also possible for students with poor finger muscles to produce a poor design despite putting more effort into their work. When that student gets a low score, he/she may not want to do that activity again.*

> *[FC_INT-5]: Etkinliklerdeki kazanımların ölçülmesi tasarım sürecinden bağımsız olmaması gerektiğini düşünüyorum çünkü süreç başından sonuna kadar başarılı bir şekilde yürütülmüşse ortaya çıkan ürün de ona göre başarılı oluyor. Ama mesela öğrencinin parmak kasları çok iyi gelişmemiş olabilir ve ürüne baktığınız zaman teknik kriterlerini tamamlıyordur fakat ortaya çıkan tasarım sanatsal ve estetik açıdan biraz daha kötü görünüyordur. Dolayısıyla etkinlik değerlendirmelerinde süreçle*

ürün bağımsız olmamalı. Çünkü bizim etkinlikteki amacımız öğrencinin bilimsel bilgiyi ve bu disiplinlere yönelik kazanımları almasıdır. Bu noktada çocuğun süreç içerisinde ne yaptığının çok iyi bilinmesi gerekiyor. Ama tasarlanan ürün genel olarak kriterlerimizi tamamlıyorsa belki sanatla ilgili çocuğu zora sokabilecek değerlendirmeler olmayabilir. Teknik olarak bir değerlendirmede en iyi olan çalışmalar seçilebilir. İkincisi estetik değerlendirmelerdir. Üçüncüsü en yaratıcı ürün değerlendirmesi olabilir mesela. Bu noktada yarıştan çok çocukların kendilerini iyi hissetmeleri de sağlanabilir çünkü parmak kasları zayıf olan bir çocuk emek harcamasına rağmen yaptığı tasarım kötü olabilir. O çocuk düşük puan aldığı zaman bir daha o etkinliği yapmayı istemeyecektir.

[SC_INT-3]: Teachers should evaluate students in accordance with the process steps they participate in activities. For example, how was the application and design part? How should these materials be combined? How the connection between them was established?

[SC_INT-3]: Öğretmenler öğrencileri etkinliklerde yaptıkları işlem basamaklarına göre değerlendirilmeli. Örneğin, uygulama ve tasarım kısmı nasıldı, bunların birleştirilmesi nasıl yapıldı ve arasındaki bağlantı nasıl sağlandı?

4.5.1.5.4 The way of developing assessment tools

The teachers' remarks demonstrated that there was a demand for various assessment tools to assess STEAM learning across the three aspects above. According to two teachers interviewed in the first camp, to develop such tools, there should be a collaboration among teachers from STEAM fields. In other words, they implied that the individual initiatives aimed to produce these tools would possibly be unsuccessful and ineffective unless they are accompanied by collaborative group work involving entrepreneurs as subject matters in different disciplines.

[FC_INT-3]: To sum up, these activities should be evaluated on a common ground. That is, the science teacher should work with teachers in other fields to measure the learning gains in the STEAM activities.

[FC_INT-3]: Sonuç itibariyle bu etkinliklerin ortak paydada değerlendirilmesi gerekir. Yani, fen öğretmeni diğer alanlardaki

hocalarla beraber çalışarak etkinliklerdeki kazanımları ölçmelidir.

4.5.1.5.5 Design principles for the development of assessment tools for STEAM learning and understanding

There are a clear need and requirement for the development of authentic assessment tools to measure learning and understandings at the intersection of multiple subjects. In this respect, it is suggested that the researchers and practitioners from different disciplines should collaborate in devising assessment instruments that can assess performance, learning, and understanding in interdisciplinary hands-on activities.

Some of the established assessment methods could be adapted for the measurement of performance, learning, and understanding in a STEAM camp such as rubric, reflection or open-ended questions, observation, peer and self-assessment form, chart, checklist, activity diary or journal, and portfolio. Evaluation of a STEAM activity could be assessed and determined based on participant's performance and learning in the project design process, final design product or prototype, and overall performance.

4.5.1.6 Interdisciplinary and multidisciplinary collaboration

The STEAM activities are interdisciplinary hands-on practices integrating objectives from multiple disciplines. The findings indicated that teachers saw the role of coordination and collaboration across disciplines as an essential building block for design, development, and assessment of the STEAM activities. The analysis of data from the interviews, open-ended questions, and survey showed the mathematics, physical sciences, visual arts, art and design, and technology-design teachers should unite and be involved in the development and implementation of STEAM activities. Specifically, four of the teachers in the first camp and three of the teachers in the second camp stated in the interviews that teachers from various disciplines, especially visual arts and technology-design, should collaboratively participate in preparing STEAM activities and integrate their discipline-based objectives into them. Similarly, two of the teachers in the second camp reported in group open-ended questions that in the camp, there should have been teachers from other fields like visual arts and technology-design. Teachers thought that the STEAM activities prepared by a joint effort would allow all the involved teachers to instill their discipline-based objectives into students. Teachers explained that involving teachers only in the preparation of STEAM activity content would be incomplete unless those teachers also took part in the implementation process.

> *[SC_INT-4]: It would be very useful if technology design teachers get involved in the activities. After all, science teachers cannot make the implementation of these activities in schools by themselves. We pay attention to such things when implementing STEAM-like activities in schools: I will do an activity in the 5th grade and ask the math teacher "did you give these concepts to the students in mathematics course?" It is because if the students do not know such information, the activity will be difficult for them. We can obtain information from technology design teachers by saying "we will organize an activity, so students come and get information from you, so will you guide them?" As a result, if we want to teach the concepts of multiple disciplines, all teachers should be involved.*

> *[SC_INT-4]: Bu tarz etkinliklere teknoloji tasarım öğretmenleri de dahil edilirse çok faydalı olacaktır. Zaten bu etkinliklerin okullarda birebir uygulanmasını fen bilgisi öğretmenleri yapamaz. Şimdi STEAM etkinliklerini okullarda uygularken şuna dikkat ediyoruz: Mesela ben 5. sınıflarda bir etkinlik yapacağım ve bunun için matematik öğretmenine soruyorum: "sen matematik de şu şu kavramları öğrencilere verdin mi?" Çünkü çocuk bu bilgiyi bilmiyorsa ve bu konu hakkinda temeli yoksa zorlanır. Teknoloji tasarım öğretmenlerinden de bilgi alınabilir: "biz böyle bir etkinlik yapıcaz, öğrenciler gelip sizden bilgi alsa, rehber olsanız?" diye. Yani birden çok disiplinin kazanımlarını öğretmek istiyorsak bütün öğretmenlerin bu işin içinde olması gerekiyor.*

> *[FC_INT-5]: Perhaps a budget like cost table can be given in mathematics activity. Performing distance measurements in the activities will also give the students the ability to measure. Similarly, in one of the activities, we used the lighthouse with circle shape. In that activity, the subject of circle can be introduced. Each student can calculate the circumference and*

volume of the material he/she uses. At this point, the teacher also needs to pay attention to the objectives of other courses gained through activities. In other words, a science teacher, who will make an activity and prepare a lesson plan, cannot know what the math and technology design objectives are to be covered in activities. Therefore, science teacher has to cooperate actively with the mathematics teacher. The math teacher may pose some questions during the activities such as preparing a lighthouse with a radius of 10 cm, how long your design's circumference should be, and how much felt you need to cut. The cost table is also very important in engineering because you will have a budget and you will make the project materials according to the budget. In addition to that, if different geometric shapes are to be used in activities, the concepts of angle measurement can be covered. For this activity, there may be a different activity sheet which will help students to make calculations.

[FC_INT-5]: Belki matematik etkinliğinde maliyet tablosu gibi bir bütçe verilebilir. Etkinliklerde mesafe ölçümlerinin yapılması çocuğa ölçme becerisi de kazandıracak. Yine etkinliğin bir tanesinde, deniz feneri, çember şeklini kullanmıştık. O etkinlikte çember konusu verilebilir. Her öğrenci kullandığı materyalin çevresini ve hacmini hesaplayabilir. İşte o noktada öğretmenin diğer derslerdeki kazanımlara da dikkat etmesi gerekiyor. Yani etkinlik yapacak ve ders planını hazırlayacak bir fen öğretmeni o sınıftaki matematik ve teknoloji tasarım kazanımlarının ne olduğunu bilemez. O zaman matematik öğretmeniyle de aktif bir iş birliği yapması lazım. Matematik öğretmeni belki etkinliklerde bazı problemler sorabilir. Örneğin yarıçapı şu kadar olan bir deniz feneri hazırlamanız gerekiyor, tasarımınızın çevresi ne kadar olmalıdır ve ne kadarlık bir keçe kesmeniz gerekiyor. Maliyet tablosu da mühendislikte de çok önemli. Çünkü bir bütçe olacak ve proje malzemelerını bütçeye göre yapacaksınız. Onun dışında farklı bir geometrik şekil kullanılacaksa açılar konusuna girilebilir. Belki ayrı etkinlik kâğıdı olabilir bunula ilgili. Çocukların etkinlik sırasında hesap yapmalarını sağlar.

The integration of STEAM activities into the school courses may not be entirely applicable or successful if only a couple of teachers become involved in the preparation and implementation process of the activities. Therefore, in situations where there are only a few teachers, the teachers suggested that instead of striving to integrate many objectives from five different fields into STEAM activities, the focus should be given on the objectives which were critical and could be taught together in the same activity. For example, as noted by teachers, science, art and design, and technology-design teachers can collaboratively work and design STEAM activities that help students learn the concepts specifically from those courses.

> *[SC_INT-4]: In STEAM activities, you tried to explain different topics through wearable technologies. I, instead, used to try to connect it with science subjects. For example, when introducing the subject of the periodic table, it may be combined with the electric circuit. As in the case of thermometer, while teaching the heat and temperature concepts, the objectives of both topics could be merged and given simultaneously. By this way, there would not be a waste of time because when we do the STEAM activities, there is a possibility that the whole subjects will not be covered. What I mean is that it is possible to combine different objectives and instill them together.*

> *[SC_INT-4]: Siz farklı konuları giyilebilir teknoloji üzerinden anlatmaya çalışmışsınız. Ben daha çok fenle bağdaştırmaya çalışırdım. Mesela periyodik cetvel konusunu anlatırken elektrik devresiyle ikisini birleştirmek olabilir. Sizin termometre örneğinde olduğu gibi ısı-sıcaklığı anlatırken ikisini birleştirip iki kazanımı aynı anda verebiliriz. Zaman kaybı da olmaz çünkü STEAM etkinliklerini yaptığımız zaman konuların yetişmeme ihtimali var. Demek istediğim burda her iki kazanım birleştirilerek yapılabilir.*

Science teachers, in their suggestions for the necessity of interdisciplinary and multidisciplinary collaboration and coordination in STEAM activities, focused intensively on the importance of arts integration. The teachers thought that arts, compared to the other four disciplines, held an essential part of a STEAM project. Therefore, the priority should be given to the arts integration in the collective efforts. At this point, visual arts and art and design teachers would play an important role in the success of STEAM activities.

> *[FC_INT-5]: We draw the designs or lines in the way we have learned in the painting class. For example, if you study my prototypes, you will see that they are very bad because my drawing is so bad. I draw geometric drawings very well, but I cannot do it when it comes to drawing curves or different aesthetic lines. At this point, I think we should work with art teachers. They can give different ideas to students during the design or implementation phase.*

[FC_INT-5]: Biz resim dersinde öğrendiğimiz tasarımları ya da çizgileri ona göre çiziyoruz. Mesela benim prototiplerimi incelerseniz çok kötüdür. Çünkü benim çizimim çok kötü. Geometrik çizimleri çok güzel çizerim ama eğriler ya da farklı estetik çizgiler geldiği zaman onu yapamıyorum. Bu noktada resim öğretmeniyle çalışılması gerektiğini düşünüyorum. Çocuklara tasarım veya uygulama aşamasında farklı fikirler verebilir.

[SC_INT-2]: In STEAM activities, you try to create an aesthetic product. The notion of aesthetic is also somewhat related to the other's aesthetic perception. For example, while the location of the Lilypad card could be a problem for us, it may not be a problem for anyone else. I think this is a purely qualitative perspective. At school, a material design course was the first course we took, where we were informed about how to make a presentation, which colors match, how to make a project, and how to design a model. I think students should be taught like that. For example, I think students should be given aesthetic understanding in visual arts classes. While I am teaching science subjects, the fashion teacher should come and talk about the fashion; the visual arts teacher should come and tell the aesthetic perception; and the IT teacher should come and tell how the circuits are established. We all must be in this together.

[SC_INT-2]: Etkinliklerde estetik bir ürün ortaya çıkarmaya çalışıyorsunuz. Bu biraz da karşıdakinin estetik algısıyla da alakalı. Mesela bizim için Lilypad kartının konumu sorun oluyorken başkası için bu sorun olmayabilir. Bunun tamamen nitel bir bakış açısı olduğunu düşünüyorum. Okulda önce bize materyal tasarım dersi verildi. Orada sunum nasıl yapılır, renk uyumları nelerdir, bir proje nasıl yapılır ve bir model nasıl tasarlanır gibi bilgiler verildi. Çocuklara da bunun dersinin verilmesi gerektiğini düşünüyorum. Örneğin, görsel sanatlar dersinde çocuklara estetik anlayışının verilmesi gerektiğini düşünüyorum. Ben fen konularını anlatırken moda öğretmeni gelip modayı anlatacak, görsel sanatlar hocası gelip estetik algısını anlatacak ve bilişim öğretmeni gelip devrelerin nasıl kurulduğunu anlatacak. Bu işte hep birlikte olmamız şart.

The STEAM camp could be applied either in or out of school settings, not just for teachers but for students as well. It can be seen from the data in Table 4.6 that many teachers (25.81% and 67.74% respectively) agreed and strongly agreed that STEAM-like camp or activities should be applied as an in-school activity.

Most of the teachers accept the idea that integrating STEAM activities into the science curriculum could bring about many benefits in teaching practice and students' learning. In the pre-assessment form at the outset of the camp, teachers were asked to indicate their attitudes towards the interdisciplinary approach and its integration into the school curriculum. Table 4.11 shows the descriptive results of teachers' perceptions on interdisciplinary approach and its integration into school curriculum.

As shown in the table, a total of 97% of the teachers agreed or strongly agreed that the interdisciplinary approach will make positive contributions to the current curriculum program. Also, many teachers (58% and 33% respectively) agreed and strongly agreed that the interdisciplinary curriculum supports schools to fulfill their learning objectives. Furthermore, many teachers don't view their field superior or inferior to other fields. For example, about 53% of teachers disagreed or strongly disagreed that the discipline they are teaching is more important for students than the other disciplines.

Besides, a great number of teachers believe that the interdisciplinary program would not be a failure like the former educational programs that have been applied previously. For instance, many teachers (47% and 47% respectively) disagreed and strongly disagreed with the idea that the interdisciplinary program would not be more successful than its predecessors. Furthermore, carrying out new approaches like an interdisciplinary program would demand considerable effort and new resources. Therefore, it could be challenging to implement new approaches. About 90% of teachers agreed or strongly agreed that it is difficult to implement new approaches without adequate resources like money and time.

It can be seen from the data in Table 4.11 that most teachers are ready and willing to work collaboratively with other disciplines' teachers and apply for an interdisciplinary program in their courses. Specifically, about 80% of teachers disagreed or strongly disagreed that it is challenging to work with teachers from other fields. Besides, many teachers (44% and 33% respectively) disagreed and strongly disagreed that they feel disturbed when it comes to using a newly revised curriculum in the classroom. Also, all the teachers (100%) agreed or strongly agreed that they are interested in learning fundamental information about the interdisciplinary curriculum. Moreover, numerous teachers (86%) agreed or strongly agreed that the professional training program equips teachers with knowledge and skills to use the interdisciplinary approach in their class.

Figure 4.8. Coding tree for thematic analysis

Table 4.11 Attitudes of Teachers Towards Interdisciplinary Approach and Its Integration into School Curriculum

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Some elements in my curriculum feature an interdisciplinary approach, although they were unplanned	0.00	2.78	2.78	69.44	25.00
I purposely incorporate material from other disciplines to prepare students for my curriculum.	0.00	0.00	0.00	77.78	22.22
An interdisciplinary curriculum would enhance student’s learning	0.00	0.00	0.00	36.11	63.89
My professional training prepared me to use an interdisciplinary approach in the classroom	2.78	2.78	8.33	63.89	22.22
I feel uncomfortable implementing curriculum change in my classroom.	33.33	44.44	22.22	0.00	0.00
I am willing to be trained/re-educated on the basic concepts of an interdisciplinary curriculum.	0.00	0.00	0.00	27.78	72.22
I would find it difficult to work with teachers from other disciplines.	19.44	61.11	11.11	8.33	0.00
Required curriculum, such as graduation standards, make it difficult to implement new ideas.	5.56	38.89	16.67	30.56	8.33
Lack of resources, such as money and time, makes it difficult to implement new approaches.	2.78	8.33	0.00	61.11	27.78
An interdisciplinary curriculum is just another "educational reform" that will not work.	47.22	47.22	2.78	2.78	0.00
Teachers in the other disciplines involved in this survey view my discipline area as less valuable than theirs and wouldn’t be interested in an interdisciplinary approach involving my curriculum area.	16.67	61.11	16.67	5.56	0.00
My curriculum is more important for students than some other disciplines involved in this survey.	8.33	44.44	19.44	22.22	5.56
An interdisciplinary approach would waste valuable class time from my discipline area	38.89	55.56	5.56	0.00	0.00
An interdisciplinary curriculum would improve upon my current curriculum.	0.00	0.00	2.78	58.33	38.89
An interdisciplinary curriculum would support the learning goals of our high school.	0.00	0.00	8.33	58.33	33.33
My current curriculum emphasizes a holistic learning experience for students	0.00	22.22	22.22	38.89	16.67

4.6 The design principles for a e-textile supported STEAM-based training program

Subject Knowledge

A STEAM camp could support the acquisition of skills in plenty of fields. Those skills could be categorized as affective skills, authentic learning skills, cognitive skills, collaborative learning skills, creativity skills, psychomotor skills, and skills in STEAM subjects.

In a STEAM activity, the STEAM connections should be transparent and meaningful so that teachers or students could be able to make and feel the connections across disciplines when getting involved in the project design process. To make STEAM connections apparent and transparent, the discipline-based objectives to be achieved at the end of the activity should be specified clearly, and activity instructions should be adjusted accordingly.

A STEAM camp could be used to give general information about the basics of electricity and circuitry, including series and parallel circuit, short circuit, circuit components, open and closed circuit, battery, current flow, and connection. Besides, it would be very useful to introduce various sensors and how they work such as the temperature sensor, light sensor, and color sensor.

Sewing

Sewing with conductive thread could be a challenging and painful process for both teachers and students. At the beginning of the camp, before starting to design the main camp activities, either teachers or students must be trained to practice sewing with both conductive thread and non-conductive thread. As a practice, for instance, a simple activity of sewing an LED and Lilypad battery holder into a piece of felt could be performed once the attendants are informed about sewing and sewable electronics. In practice, teachers should be thought basic sewing skills such as how to make a knot and running stitches and to sew loops around a sew tab.

Circuitry

Despite grasping a profound theoretical knowledge about circuitry and electricity, science teachers tend to struggle to transfer that knowledge into the project circuit. Also, despite seeing circuit diagram, they could still have difficulties in making a fully functioning project circuit. Therefore, it could be an effective method to give necessary information on how the current flow (short circuit), connections (series and parallel circuit), and polarity issues happen and how to avoid making them in the first place in e-textile circuit designs.

Art

The STEAM activities could enable teachers or students to elicit and evolve their art skills during the project design. The variety of crafting and textile materials should be increased to allow participants to use their art skills. Giving groups a degree of autonomy and freedom over the project design and letting them choose whatever crafting and textile materials they want could give impetus to the development and use of artistic skills in STEAM activities. Besides, demonstrating previously designed project exemplars and organizing field trips related to the camp could stimulate participants' artistic thinking in their project design.

Creativity

The use of creative skills should be encouraged in the camp. Engaging in crafting STEAM projects in the camp could flourish creativity and encourage its use.

It is likely to nurture creativity in the camp in several ways. For example, the construction of project design as a solution to the problem posed in the activity scenarios should bring a solution to the real-life problems prevailing in the society or the surroundings. Also, there should be constraints on the number of sewable electronics used in each activity. Exemplary design projects should be shown to the groups in advance of the activity to inspire and help them develop innovative ideas about their project design.

Participants shouldn't be forced to make a particular type of design. Instead, each group itself should have a monopoly on their project design.

Scaffolding

For a STEAM camp with teachers, there should be an adequate number of facilitators to facilitate group design processes throughout the camp. At least five facilitators should support a camp with ten groups of two teachers. One of the facilitators must be familiar with the tools and materials used in the camp. Also, at least one facilitator should be knowledgeable about wearable e-textile technologies, circuitry, and Arduino coding. Besides, all the facilitators should have practiced sewing with conductive thread several times.

It is better to reduce the level of instructional scaffolding after certain stages of the camp. Because, in times, teachers have become competent in doing some of the activity tasks by themselves.

Group forming

A group should be composed of either two or three members. However, a group of two participants could be more efficient. Besides, the distribution of sex in a group should be kept equal. In a group, there should be at least one man and one woman, depending upon the group size.

Two group forming methods, self-selection, and random assignment, could be used to form groups in the camp. In the first activity, teachers or students could be allowed to create their group without any intervention. However, in the activities followed, it is better to switch between groups randomly.

In contrast to teachers, students in a group should be at the same grade level.

Wearable e-textile technologies

At the beginning of the camp, it is necessary to present participants with elaborative information about the flow of the camp and the camp materials, specifically wearable e-textile technologies. It could be sufficient to separate at least two hours to explain each of the activities in detail, such as the sorts of sewable technologies used in the activity, the functioning of these technologies, the way they are connected, the design process to be followed, and so on.

In case teachers or students are unfamiliar with the Arduino development environment and the Lilypad, it is better to demonstrate them the basics of Arduino coding platform at the beginning of the camp such as how to upload the code into the project circuit and to connect Lilypad to the computer without damaging it.

A group project should be conducted at the end of the camp. Besides, there could be a presentation session at the end of each activity where each group presents their projects to other groups. Also, the camp could be followed by an exhibition of all the projects designed by groups throughout the camp.

Interaction

Collaborations within and between groups should be encouraged in a STEAM camp. Conversing with group members or other groups and sharing ideas, opinions, experiences, and problems related to different parts of the project design could spark interactions and collaborations within and between groups.

Forming groups with a mix of teachers from different disciplines will presumably foster interaction and collaboration within and across groups. Also, group members should switch after each activity to increase the possibility of their interactions and learning exchange with various people.

Activity Structure

Each STEAM activity should have three crucial activity content components: problem scenario, circuit diagram, and design thinking stages.

It is better to organize the content sequence of the hands-on STEAM activities from simple to complex. Besides, the degree of difficulty and elaboration in the contents of the activities should be adjusted to the participants' levels and understandings.

Problem-based activity scenario

There must be a problem scenario in each STEAM activity, and it should have some essential characteristics. For instance, the content of the scenario should be straightforward and out of unnecessary details and abstract wording. Also, the problem posed in the activity scenario could be obvious to everyone who can read it.

The problem described in the activity scenario must be relevant to real-life situations, matters or contexts. Besides, the problem scenario should be designed to reflect attendants' cultures, values, interests, and surroundings rather than be about imaginary things or objects.

Circuit diagram

The circuit diagram should be attached to the activity form not only for students but also for teachers as well. However, for the teachers or students who have practiced similar activities before, the circuit diagram could be excluded from the activity form.

Design thinking stages

STEAM projects could be designed based on the design thinking stages. Teachers or students should be encouraged to stick to design thinking stages while creating their STEAM projects.

Safety precautions

Some of the sharp and cutting tools used in the camp could lead to injuries such as needle, scissors, cutter knife, craft knife, etc. To control this risk, all of the attendants, especially students, should be warned about the hazards of using such tools and also instructed how to use them safely at the outset of the camp.

Camp setting

A STEAM camp should be implemented in a large space with adequate lighting and an air conditioning system that can supply both warm and cold air as well as circulate air in the camp area. Also, there should be technological facilities like easy access to electricity and the internet via wireless technologies. Besides, several electrical accessories like power plugs and power extension cables should be available in the camp.

There should be a large round or rectangle table for materials and tools that are commonly used by groups. Also, there should be an adequate number of chairs and a medium-size moveable round table for group work.

Camp duration

A STEAM camp with seven hands-on activities, as well as the final group project, could be performed in four days. A typical camp day could start at 9:30 am and close at 4 pm with an hour lunch break and five minutes break between activity sessions.

It could be challenging to apply the four-day camp curriculum to students due to their immature abilities, which play a significant role during the design process. The camp time, therefore, should be increased for students and at least ten minutes break between activities should be given.

Food and beverages

The tea, coffee, and water should always be available during each day of the camp. Each morning of the camp day, half an hour before the camp starts, some sorts of snacks could be serviced along with the tea and coffee. The snack service should be made two times a day: morning and mid-afternoon. Besides, it could be better to make a four-day lunch reservation for all participants in advance of the camp.

Materials and tools

The materials and tools used in the camp must be in sufficient quantity and diversity so that teachers or students could be able to harness their full potentials and skills. Besides, it would be preferable to increase the diversity of textile and craft materials.

There might be some improperly functioning sewable electronics, and those broken pieces could later result in irreparable circuitry problems. That's why all of the technologies should be checked and controlled in advance.

Some parts of the sewable electronics could be broken easily during the project design, especially the Lilypad Arduino board. Bring additional several sewable electronics to the camp could minimize the effects of such kinds of unfortunate incidents on the group's motivation, and also, the broken one could be replaced.

Communication and collaboration between stakeholders

Organizing and implementing a STEAM camp in school hold an array of challenges that could only be managed by strong communication and collaboration between stakeholders, including teachers, school administrator, and parents.

Interdisciplinary collaboration in the development of STEAM activities

A STEAM activity should involve multiple objectives from multiple disciplines. A teacher must work in coordination and collaboration with other teachers from different fields to prepare STEAM activities and integrate their discipline-based objectives into them. It is advised that STEAM activities shouldn't be developed by those who are not the subject matter in STEAM fields. Likewise, developing a STEAM activity is not a job that could only be performed by one or two teachers in isolation with other relevant areas. Because, in STEAM activities, learning of a concept or skill in science is more likely to be more meaningful and permanent when connected and related with another concept or skill in arts, mathematics, engineering, and technology.

Teachers from multiple disciplines should work together and search for a common ground where each teacher could instill her\his lesson-based objectives into students in combination with other disciplines' objectives. Besides, the discipline-based objectives addressed in STEAM activities should be consistent with the educational program.

Every individual teacher should collaborate with other teachers for the purpose of instilling her\his lesson-based objectives into students. To do that, they must find common ground where they could give their objectives in combination with other objectives. The coordination and collaboration between STEAM teachers must not be limited only to the process of developing activities, but also to the process of implementing them. Furthermore, comparing to other disciplines, more efforts should be given to the integration of arts into STEAM activities. Additionally, teachers' collective and joint effort to design hands-on activities should concentrate on abstract concepts rather than the concepts that are straightforward and easy to comprehend.

For the implementation of STEAM activities, in addition to the professional skills, science teachers must possess a repertoire of flexible and versatile skills to manage the activities and deal with the problems about many different aspects including technical, technological, artistic, coding, etc.

Teachers' collective and joint efforts to design hands-on activities should concentrate on abstract concepts rather than the concepts that are straightforward and easy to comprehend.

Interdisciplinary collaboration between different fields shouldn't be limited in the preparation process of hands-on activities; it should also be continued during the implementation of the activities.

Science teachers' motivations to participate in the camp

Developing professional knowledge and experiences as to different subjects could be the main driving force that brings teachers to the camp. Teachers could be interested in possessing basic knowledge and skills in wearable technologies, getting familiarity with new educational technologies, transferring camp's learning and experiences to school settings, integrating STEAM-like hands-on activities into their courses, increasing the knowledge base for the national grant projects, learning

Arduino programming language, and experiencing the integration of arts into STEAM activities.

Assessment of STEAM learning and understanding

Authentic assessment tools should be developed under the supervision of researchers and practitioners from different disciplines to measure STEAM learning and understandings.

Some of the existing assessment tools such as rubric, reflection or open-ended questions, observation, peer and self-assessment form, chart, checklist, activity diary or journal, and portfolio could be adapted to use for assessing participants' performance and learning in a STEAM activity.

Assessment of STEAM learning and understandings in a hands-on activity could be performed in three parts: project design process, final design product (or prototype), and overall performance.

Issues and challenges

Problems, issues, and challenges are part of a STEAM camp that could be alleviated or completely removed with proper strategies and interventions taking place before, during, and end of the camp.

Teachers or students could face many challenges from sewing and circuitry to design, time, crafting, and materials.

CHAPTER 5

DISCUSSION AND CONCLUSION

Throughout this chapter, the primary study findings are discussed, with emphasis on the emerged themes or categories, and meaningful conclusions are drawn by referring to the relevant literature. The organization of this chapter is as follows: The first part briefly informs the readers about the essential elements of the study, such as research questions, the research method, etc. The second part presents the discussion as to each of the research questions in consideration of the related prior study findings. The third part covers a STEAM camp design guideline. The last section includes the implications of the findings and recommendations for future research studies.

5.1 The brief overview of the study

Engaging in hands-on projects and building some kinds of artifacts has always become the natural way of learning something concrete and abstract. This study prepared STEAM activities that combined sewable electronics with crafting, sewing, and design. The aims of this study are three-fold: to explore the design principles of sewable electronics-based STEAM training camp; to investigate the design, development and usability issues of wearables technologies supporting STEAM-related activities in middle school students; and to examine the extent to which teachers can apply STEAM camp training results and experiences in their courses. The research that was theoretically rooted in the constructionism paradigm employed the design and development research to examine the effects of wearable e-textile activities on the learning of the concepts of electricity and circuit from the perspectives of science teachers.

An e-textile wearable technology-based STEAM curriculum program was prepared for middle school science teachers after a few rounds of piloting. The curriculum program that consisted of seven problem-based, hands-on activities, as well as a final group project, was then implemented by two independent groups of science teachers in two four-days-long camps. In both camps, science teachers, as a group of two or three, worked together and designed their STEM projects following the design thinking stages. While making and crafting their project designs, they exploited a broader range of resources, from programmable microcontrollers to a variety of sewable sensors and fabric and textile items.

Science teachers' experiences and subjective opinions on different aspects of the STEAM activities were captured using various data collection forms, including interviews, pre and post surveys, activity evaluation forms, observations, and artifacts (STEAM project designs). The interviews provided the core data, triangulated with observations, pre-and-post open-ended questions, survey data, artifacts, and photos of teachers' STEAM design processes. The in-depth analysis of the qualitative and quantitative data culminates with five main themes and associated subthemes, namely experiences and opinions, expectations and satisfaction, perceived benefits, challenges, and suggestions.

5.2 What are the design, development, and usability issues of e-textile supported STEAM-based activities?

The study sheds light on numerous challenges experienced by teachers in the camp, and the possible problems teachers could face when they implement similar activities in the classroom. Most of the teachers reported grappling with coding a wearable project circuit, crafting a project design with the artistic merits and values, designing a fully functioning circuit, avoiding short-circuiting, drawing a design sketch, making the transition from sketch to project design, coming up with a unique design solution, and sewing an electronic circuit into the fabric. Besides, despite putting great efforts into the project design, teachers as groups tended to be unsuccessful in completing their STEAM project design within the specified time. Some of these challenges faced by teachers in the camp have been identified in previous e-textile studies that used samples of students (Litts et al., 2017; Searle et al., 2018). For example, Litts et al. (2017) reported that most students were incapable of reading and remixing a piece of codes for the e-textile project and designing a fully functioning e-textile circuit. Likewise, after examining students' debugging and failure experiences in open-ended e-textile projects, Searle et al. (2018) reported two common challenges: sewing with conductive thread and design of spatial circuitry.

Interestingly, in an e-textile equation, if teachers replace students, no significant change seems to appear in terms of reported challenges and failures. Some underlying ideas could be drawn based on these findings. First, there are certainly some challenges inherent in the design of art-focused wearable e-textile activities like sewing, circuitry, design, and aesthetics. Second, the existing teacher education programs fail to prepare teachers for the interdisciplinary classroom practices that are considered to play a vital role in students' STEAM careers and participation (Baran et al., 2019). Third, having severe problems even with the basic concepts of circuit and connectivity such as polarity, connection type, and current flow does not imply that teachers have the poor subject matter knowledge (Holstein & Keene, 2013), but it could probably mean that they suffered from translating their subject knowledge into a usable and applicable form in real-life contexts or situations.

Besides, the supposed inherent connection and dependence of science knowledge to the knowledge in other disciplines in hands-on activities (Litts et al., 2017) could underlie science teachers' leading problems associated with STEAM activities because it seems that teachers' challenging experiences with STEAM activities mostly stem from their inability to connect concepts from different subjects with which they utterly or partly unacquainted or unfamiliar. Differently, it was apparent from teachers' STEAM sample designs that except science subjects, most teachers seemed to deprive of fundamental knowledge and understanding in other disciplines, most notably in arts, technology, and engineering. It is even plausible to claim that teachers' general knowledge of art and artistic values do not go beyond the improvisational creative efforts. Therefore, STEAM activities are likely to be challenging for teachers unless they experience interdisciplinary training or learning programs where the concepts from different disciplines are connected and introduced together.

The kinds of challenges teachers thought students would encounter as to the making of STEAM activities would be akin to those faced by teachers in the camp. For instance, most of the students most probably would have the same faith as most teachers in the camp who demonstrated a deficiency of sewing skills and even fundamental problems with circuitry. Students' sewing and circuitry struggle could be even a bit more severe than teachers due to their immature fine muscle skills and lack of knowledge of science subjects. It is also highly possible that students would have difficulties in crafting and coding STEAM project design as well. However, the level of these challenges could be mitigated by preliminary training exercises given by those who are experts in helping students alleviate those challenges.

The current research also unfolded some other significant hurdles that could intervene in the integration of STEAM activities into the classroom. These challenges ranged from teachers' inability to handle an excessive number of students in a classroom to inappropriateness of the current physical classroom space for the activities, insufficient in-school time for making activities, stakeholders' avoidance of making a commitment to involve in the integration process, and public schools' low budget to afford to buy activity materials and tools. These results match those observed in earlier studies. For instance, Park et al. (2016) found that teachers struggled to implement STEAM lessons in their classrooms mostly due to the deficiency of time, excessive workloads, and low administrative and financial support. Likewise, Nugent et al. (2019) reported that teachers struggled to find time out of the formal curricula to implement e-textile activities. In addition, Hira et al. (2014) outlined a range of pedagogical challenges that could hinder the implementation of maker activities into the classroom context such as reliance of current educational system upon success on standardized test, stakeholders (parents, principals, teachers, and students) concerns about teacher preparation, technology and resource management, and diversity. Besides, Litts et al. (2017) discussed that teachers would need sufficient knowledge and familiarity with the intersecting disciplines so that they could support students during the implementation of the activities. The research presented here sits mostly at the intersection of design, crafting, technology, science, and engineering. This study provides ample evidence that teacher training initiatives like STEAM training camp can equip teachers with the necessary knowledge and experiences about the intersecting disciplines and thereby facilitate the integration of STEAM activities in-or-out of school settings. In the context of concerns over the integration of hands-on science learning activities into school curriculum, these findings are particularly noteworthy.

The findings of this study showed that school administrators' and parents' position on use of STEAM training program in school hold a significant value for teachers to carry out STEAM activities in classroom. In other words, several teachers in this study expressed their concerns, which is considered to be important, that school administrators and parents are likely to stand against the implementation of STEAM training program in their school. It appears that teachers are aware of the importance of school administrators' decisions about the adoption of interdisciplinary programs and student's parents' intention and desire to prepare their children for STEM or STEAM related careers. Yet, it was recently reported that parents were hardly aware of STEM education and its contributions to their students (Watson et al., 2020). Therefore, we called for instructional efforts, programs or initiatives to inform parents as well as school administrators about STEAM practices and its potential benefits for the preparation and success of students in STEM careers and university.

This study suggests that a STEAM camp could give teachers the necessary skills and abilities to implement the same or similar hands-on activities in their school. However, a teacher's implementation of the camp program in school could be impeded by several factors like the availability of the time, suitable place and conditions, and most importantly financial supports. In addition to that, most of the public schools especially in rural areas could not afford to buy the camp materials and tools, particularly sewable electronics, without any financial support from other institutions, for example, Ministry of Education, Scientific and Technological Research Council, etc.

Further, a large amount of study data highlighted that engaging in designing and crafting STEAM activities would bring about a range of potential benefits to not only students but also teachers. Those benefits include the development of affective skills, authentic learning skills, cognitive skills, collaborative learning skills, creativity skills, and psychomotor skills and grasp of skills and knowledge in fundamental subjects (science, technology, engineering, arts, and mathematics). Regarding to the students, some of these findings converge with those of previous e-textile studies that found an increase in students' understanding of circuitry concepts (Litts et al., 2017; Peppler & Glosson, 2013), learning outcomes and motivation (Tofel-Grehl et al., 2017), STEM learning and attitudes (Nugent et al., 2019), and interests and participation in computing and crafting (Kafai et al. 2014). Moreover, these results are consistent with the recent empirical evidence from previous studies, reporting that STEAM activities created a significant effect on students' creativity (Casado Fernández & Checa Romero, 2020; Ozkan & Umdu Topsakal, 2021a) and understanding of science concepts (Ozkan & Umdu Topsakal, 2021b).

Involving in STEAM activities did not only give teachers to explore art-focused STEAM pedagogies, but it also made them more knowledgeable and confident about implementing the same or similar activities in their school. These results further support earlier studies (Kim & Bolger, 2017) which found that teachers' confidence in creating STEAM materials is boosted after they participate in designing STEAM lesson plans.

5.2.1 Summary

After monitoring teachers' various design processes of e-textile projects and analyzing a bunch of data types, this study explored that some of the issues associated with design and development in STEAM activities are intertwined. In other words, it seems to be challenging to set boundaries between the problems taking place during the design and development of sewable activities. Yet, these issues need to be specified so that STEAM-like activities could be refined and further developed by the teachers who play roles as developers and designers.

5.2.2 Design issues

Designing a series of STEAM activities allowed science teachers to explore and dealt with several design issues. In the study findings, sewing with conductive thread, making stitches, building a working circuit, sewing circuit components into the fabric, and producing a creative design solution stood out as being more visible problems. There were other important issues, as well. For instance, the period of transition from sketch to design was blurry and chaotic. In other words, there was neither prospective thinking in drawing a design sketch nor systematic planning in converting the finished design sketch into a tangible design.

5.2.3 Development issues

Since it is an overlap between the design and development sections due to the nature of the STEAM activities, some of the issues described here could also belong to the design part. It was clear from the study findings that in order to further develop the current STEAM design, apart from professional expertise, additional knowledge and experience are required in other subjects, especially technology, electronics, and arts. In addition to that, it seems that the reason teachers got stuck in failing to invest artistic and crafting skills in project design is that they may lack fundamental interdisciplinary knowledge and understanding, and therefore there are naturally unable to make meaningful connections across intersecting subjects in STEAM activities. Herro and Quigley (2017) reported corroborating evidence, showing that teachers (science and mathematics teachers) had limited understanding of STEAM. Besides, it is rather considered that the fact that STEAM activities were prepared in a structured way may have disrupted teachers' efforts in developing their projects. Furthermore, study findings spotlighted teachers' lack of knowledge in sewable electronics and coding, which was an essential factor in development-related issues.

5.2.4 Usability issues

This study asserts that STEAM activities have a high potential for different uses, and therefore they could be considered as versatile projects in science and technology fields. However, a person or an institution could face some big hurdles in putting them into use in either outside or inside of the school setting. The usability issues are explored to be derived from three aspects: teacher, school, and student. For the first aspect, teachers, as the number of students increases in a classroom, the teacher's ability to manage and facilitate students' STEAM projects is highly likely to decrease. Furthermore, teachers might deliberately avoid conducting activities due to the efforts and responsibilities required during the preparation of the activities. Besides, teachers may have a lack of knowledge and experiences in STEAM subjects. As for the second aspect, school, it seems that the current school environment, like classrooms and laboratories, is not suitable for implementing such activities. Also, since STEAM activities require relatively a bulk of time, making activities would be too tricky with the current in-lesson time. The school budget appears to be another situation that hinders the use of STEAM activities. Suffering from budget deficit might not allow schools to cover the cost of activity materials and tools. For the last aspect, students, the prepared activities may not be appropriately used in lower grade levels, like pre-school and primary education, because a certain level of abilities, especially psychomotor skills, must be grasped beforehand.

5.3 To which extent teachers can apply STEAM camp results in their courses?

Adoption of integrated STEAM pedagogical practices has been proven to be a painful and tedious process (Herro & Quigley, 2017; Kim & Bolger, 2017) involving the participation and pre-preparation of multiple agents. The efforts to find out the merits of incorporating e-textile activities into science courses have been focused relatively more on students (Nugent et al., 2019) and tended to bypass teachers as if they are less critical than students in the integration process. This study, however, strongly asserts that teachers are the main agents who ensure successful STEAM activities preparation and implementation. That's why they should be equipped with the knowledge and skills, as well as experiences, required to make these hands-on problem-based activities from scratch (Searle et al., 2019).

The STEAM training camp in this study was an intentional and effortful attempt to seek how in-service public-school science teachers feel confident and consider themselves adequate to move training camp experiences from out-of-school space into science courses. The results revealed that irrespective of the challenges associated with STEAM activities, all the teachers participated in the STEAM training camp reported that they acquire the ability to implement STEAM activities in their school and to successfully transfer camp knowledge, skills, and experiences into the science classroom. Besides, a significant number of teachers appeared to be very keen and enthusiastic about doing STEAM activities together with their students.

Teachers' ability to convey camp skills and knowledge to the classroom was strengthened by further after-camp evidence. After returning to their schools, four teachers were able to successfully introduce their students with either all or some of the STEAM activities and let them design their first STEM projects and having fun while learning science and electronics.

It is seen that some studies have been undertaken to develop teachers' knowledge about e-textile activities and materials. For example, using an e-textiles curriculum in middle science classrooms, Searle et al. (2019) introduced science teachers and non-dominant female students how to do e-textiles projects. However, different from the current study, they only documented the students' engagement of with e-textiles projects and materials.

Despite teachers' self-reported belief in their ability to make hands-on activities in the classroom, they still need seeking technological and pedagogical support from teachers of other disciplines or experts outside of the school (Litts et al., 2017). Teachers' unfamiliarity with the intersecting disciplines, which is naturally inherent in STEAM activities, is likely to disrupt and hinder their efforts and initiatives to transfer camp skills and knowledge. In literature, pre-service teachers largely attributed their difficulty in making STEAM lesson plans to unfamiliarity with STEAM subjects (Kim & Bolger, 2017). It is obvious that science teachers may not be expected to hold knowledge in all STEAM areas, but they can benefit from disciplinary knowledge and experiences of teachers from other fields by working in collaboration with them. In this study, most teachers regarded the role of coordination and cooperation across STEAM disciplines as an essential building block for design, development, and assessment of the STEAM activities. All the science teachers firmly believed that teachers from other fields like visual arts and technology-design should joint them and involve in preparing and implementing STEAM activities in school. These findings corroborate previous views that art and design teachers should cooperate with teachers in STEM fields on how to develop a STEAM curriculum (Bequette & Bequette, 2012; Wynn & Harris, 2012). It should be underscored that forging this joint and collective effort is rather essential because it could allow every teacher involved to partner and learn from each other (Wynn & Harris, 2012) and integrate their discipline-relevant standards into activities, and thereby to instill their discipline-based objectives in students.

5.3.1 Summary

An increasing and ongoing debate over the integration of e-textile-centered pedagogies into the school curriculum has provoked the question of what strategies could be deployed to make the integration process more manageable, productive, and safer. So far, not much data has been remained uncovered about this topic. However, the findings of this study, which were fed by multiple data sources, revealed some vital information concerning the teachers' e-textile experiences and abilities to convey those experiences from a training camp to school lessons. That is to say, this study clearly showed that teachers could significantly apply STEAM camp results in their courses. Besides, thanks to the camp, they felt exceedingly confident and become very eager to use e-textile knowledge, simply learnings and experiences from the STEAM camp, in science courses. The finding is that STEAM camp proves itself useful in terms of equipping teachers with e-textile knowledge and using that knowledge in school does not only come from teachers' self-reported data. There is after-camp evidence as well, showing that several teachers have effectively implemented some of the STEAM activities in their science courses. These findings together suggest that professional training programs like STEAM camp could be developed as a pedagogic strategy to inform and educate teachers about STEAM-centered approaches. A similar call is made in other studies (Herro & Quigley, 2017; Zhu, 2020). In her research, Zhu examined perceptions and understanding of STEM teachers about maker-centered pedagogies and how they are willing to use these approaches in their courses. The concerns that were laid out by teachers pointed out the need for teacher training in STEAM-centered pedagogies.

It may be argued that learning and implementing STEAM practices would impose an additional burden on science teachers who have already been constrained by curricula requirements and insufficient planning time. However, collaboration could play a key role at this point to assist teachers to improve STEAM practices and implement them in their classrooms. As underlined by most of the teachers in this study and previous research (Herro & Quigley, 2017; Lesseig et al., 2016; Margot &

Kettler, 2019), science teachers ought to collaborate with teachers in other STEAM subjects and work along with them on activity preparation and implementation. Involving university faculty in the process are likely to be even more productive.

5.4 What are the design principles for e-textile supported STEAM-based activities?

Professional development (PD) programs play a crucial role in improving teacher education and student learning. With the continuing increase in STEM and/or STEAM education initiatives among K-12 public and private schools (Herro & Quigley, 2017; Park et al., 2016), these programs have become even more valuable on account of holding great promise for the training of teachers about STEAM literacies. A recent review study showed that PD programs, which were conducted in face-to-face workshops and rely on multiple hands-on activities, assist teachers to improve understanding and knowledge related to integration of engineering concepts and practice into classroom instruction and to foster positive beliefs and attitudes toward integration of engineering (Mesutoglu & Baran, 2020). A PD program's success in helping teachers explore STEAM practices depends upon how well it considers the participants' needs and demands. A well-designed PD, therefore, should stick to the teachers' shared expectations and prepare its content accordingly. Various factors could drive in-service teachers to broaden their practical and professional knowledge in STEAM-centered approaches. In this respect, this study revealed important findings regarding the science teachers' motives in participating the STEAM camp program. The current study findings showed that science teachers came to the camp with the purpose of primarily acquiring basic knowledge and skills in wearable e-textiles technologies, getting familiarity with new educational technologies, transferring their new learnings and experiences to school settings, integrating STEAM-like hands-on activities, especially creativity and arts-based learning, into their courses, and learning Arduino programming language.

In this study, the pillars of STEAM activities stand on maker-centered pedagogies. Previous studies using these pedagogies with different educational tools reports corroborating evidence for the design principles explored in this study. For instance, in their research, Ucgul and Cagiltay (2014) investigated design principles for an educational robotics training camp, using a sample of elementary school students. The design principles they explored pointed the necessity of prior knowledge about activity components, the encouragement of social skills during the activity, group size and gender composition, the problems derived from the group working, importance of coaching, issues raised from activity materials, the challenges faced during the design of the activity, and camp duration. Compared to the robotics activities that mainly focused on programming skills, the activities utilized in this study focused on e-textile technologies and crafting tools and addressed versatile skills, which therefore accommodates diverse design elements.

5.4.1 Structure of the STEAM activities

Structured activities compared to its counterpart, unstructured activities, appear to be fruitful in the learning settings where teachers lack knowledge and experiences in e-textile technologies. The purpose of using a structured form in STEAM activities was to guide each project group to exclusively follow design thinking stages because, as revealed in the study, project groups tend to follow their own intuitive and tentative design strategies. The current study provided rich evidence that in the STEAM activities the activity sheet becomes an invaluable asset to project groups. With its three fundamental elements, problem-based activity scenario, circuit diagram, and design thinking stages, a hands-on activity sheet functions as a detailed map guiding groups to stay on the road throughout the project design. Otherwise, groups could stand still with activity materials and do not know what to do next. For that reason, it is advised that an activity sheet, which is handed to project groups, should necessarily include activity scenario and circuit diagram.

5.4.2 STEAM as subject knowledge

We recognize that STEAM activities embrace artistic and creative thinking as much as circuitry and design thinking. It is, therefore, essential to make sure that both artistic and creative skills are cultivated successfully during the engagement of the activities. The importance of aesthetics in e-textile activities and its effect on learning have already been recognized (Kafai et al., 2014). Acknowledging that maker activities, by its very nature, have the artistic and creative aspect, this study proposed a couple of instructional strategies to inspire participants to elicit innovative ideas and stimulate their art and creative skills. These methods include giving participants a degree of autonomy and freedom to a certain extent over the project, demonstrating exemplary project designs at the beginning of the camp, and encouraging participants to create a design that brings a solution to the real-life problems prevailing in the society or the surroundings. These results are in agreement with previous research, showing that creativity and autonomy contribute to cognitive learning in a STEAM hands-on task (Thuneberg et al., 2018). Even though e-textile construction kit is known to encourage creativity and autonomy, it is important to keep autonomy on the level of teachers' familiarity with STEAM practices.

Novice designers like teachers or students who are devoid of understanding of sewable electronics and have less familiarity with activity materials are doomed to face challenges in STEAM activities (Peppler, 2013b). Even if teachers assert that they are acquainted with basic circuits and electronics, they are likely to end up with many disturbing and humiliating experiences in the process of designing a STEAM project. Because, just like students, teachers might incline to treat sewable electronics as if they are traditional electronics, like a conductive thread as wire, sewing lights as buttons, and so on (Kafai et al., 2014; Tofel-Grehl et al., 2017). Therefore, a training session is highly recommended at the outset of the camp, in which the camp participants should be informed about sewable electronics, circuitry, and sewing with conductive thread and be prepared to handle the possible issues that could disrupt the design process.

In addition to the basic knowledge in fabrication technologies, teachers at least need to have basic concepts and understandings in STEAM areas so as to prepare and implement interdisciplinary practices. However, it seemed that teachers' conception of STEAM education or practices was so blurry and foggy that they do not know what they are supposed to be or know when it comes to the merging of isolated disciplines. Besides, despite acknowledging its value, teachers are not familiar with the content of STEAM education (Hsu et al., 2011). The main reason could be due to the fact that the current national teacher education program in Turkey is heavily dependent upon professional and pedagogical content knowledge, which makes prospective science teachers graduate unprepared for other STEAM pedagogies, particularly arts, technology and engineering. This is where STEAM camp become an important alternative instructional strategy to educate teachers about STEAM activities and the technologies used and to help them enact these practices in their schools.

5.4.3 Collaboration and interaction

This study showed that the role of interaction in STEAM-focused programs is undeniably important and cannot be pushed aside when it comes to the implementation and integration of these programs in different learning settings. Interdisciplinary teachers' involvement in the entire program process from the preparation to implementation of hands-on activities is therefore indispensable for achieving the intended goals and objectives. We suggest that in order to mitigate STEAM integration process, collaboration must be established so that teachers of different subjects can connect STEAM concepts meaningfully.

All of the teachers in this study attributed the success of STEAM activities in learning settings to collaboration across different disciplines, which is why reciprocal interaction within cross-curricular level is deemed necessary to establish meaningful connections across STEAM subjects. Like this study, teachers in other studies also attributed the success of STEM or STEAM practices in learning settings to collaboration across disciplines (Al Salami et al., 2017; Herro & Quigley, 2017; Stohlmann et al., 2012). Yet, certain challenges are inherent in cross-curricular teaching in STEAM-centered practices. Those challenges are highly likely to be manifested in curriculum, pedagogical, and structured levels (Margot & Kettler, 2019). Most of the teachers in this study, for example, believe that parents and school administrators would also have a valuable role in the implementation of STEAM activities. However, they are concerned that some grade and budget-related factors could lead them to avoid participating in integration process.

It was extremely clear from the existing research result that strategic partnership must be established to forge collaboration between teachers (or researchers) of various fields in the development and implementation of STEAM activities. Because, the activities targeting maker and hands-on experiences and learning like the ones in this study require a repertoire of flexible and versatile skills from technical to technological, artistic, coding, and computing, which is, however, not merely possible for a single teacher to possess all of them. Working in collaboration with other teachers of different disciplines could allow every individual teacher to integrate their discipline-based objectives into STEAM activities in harmony with other disciplines' goals. Furthermore, in order to increase the viability of the STEAM-like activities, schools are advised to create partnerships with other schools, university faculty, and institutions for benefitting from their knowledge and expertise (Lehman et al., 2014). Besides, it might be better to use STEAM activities for the understanding and learning of the abstract concepts rather than the concrete and tangible concepts that taught quickly by traditional methods.

Interaction in STEAM activities appears to be a key ingredient that makes learning to be interactive within and between group of science teachers. The study findings showed that undertaking multifaceted tasks during the STEAM project design drives science teachers to ask for help or assistance from either their group member, teachers in other groups or facilitators. It seems that most of the behavior that trigger such interaction emerges when participants look for alternative design ideas or are stuck with the issues related to design and use of e-textile materials. It is certain that interaction must prevail among science teachers throughout the camp, but there could be some teachers who refrain from sharing their difficulties and seeking assistance because of either having more self-confidence in their abilities or feel shy or ashamed of being seen unskilled. It is the facilitators' job to monitor each project group closely and detect isolated teachers and then give special attention to them.

5.4.4 Assessment

The research results also emphasize the need for designing and developing assessment tools to measure STE(A)M learning and understanding, which seems to be quite challenging due to multiple overlapped domains in maker activities. Some initiatives have already taken, but the offered assessment instruments either focus on a particular aspect of STEAM learning (Peppler & Glosson, 2013) or capture narrow interdisciplinary knowledge and literacies (Blikstein et al., 2017; Litts et al., 2017). Science teachers in this study suggests that various assessment forms could be used to measure learning outcomes in interdisciplinary projects such as rubrics, reflection or open-ended questions, observations, peer and self-assessment forms, charts, checklists, activity diaries or journals, and portfolio. They also underline that these forms should be developed as a result of a collective and collaborative work among the academic community, researchers, and teachers. It appears that one form of assessment tool is not enough to measure multiple content knowledge. Besides, the available assessment tools are prepared for the purpose of assessing single layered disciplinary knowledge. Therefore, researchers or teachers from STEAM fields should gather and work collaboratively to develop an instrument having ability to measure learning of multiple disciplines.

5.4.5 Organization

A camp duration might vary and be determined depending upon a wide span of factors, for example, the number of hands-on activities and participants and instructional objectives aimed to achieve. Previous studies on e-textile technologies conducted similar camps/workshops with students that spanned nine two-hour-long sessions (Searle et al., 2018), ten weeks(Kafai, et al., 2014), and two weeks (fourteen two-hour-long sessions) (Peppler & Glosson, 2013). The studies took place voluntarily, either in school spaces (Nugent et al., 2019; Searle et al., 2019) or out-of-school spaces (Peppler & Glosson, 2013; Pinkard et al., 2017; Searle et al., 2018). A better decision would be to have the designer(s) of the camp activities to determine the amount of time for each activity and the whole camp duration.

5.4.6 Issues and challenges

Issues and challenges are part of a STEAM training camp that are very difficult to escape from. In fact, as the variety of materials and complexity of activity increase, the number of problems faced by project groups rises. The results of this study indicate that while working on their STEAM projects science teachers ran into various issues and challenges, which surprisingly resemble those expressed by students in studies on maker-centered pedagogies (Litts et al., 2017).

5.4.7 Instructional strategies

Instructional strategies can significantly affect both the quality and quantity of the intended learning outcomes in maker-centered learning environments. Science teachers in this study were novices in wearable e-textile technologies, crafting, and sewing with conductive thread. Therefore, they needed and continuously asked for immediate assistance in finding solutions to their problems from facilitators while designing e-textile projects. The hands-on activities in this study are largely centered on problem-based learning (Papert, 1980, 1993). The problem-based learning can be combined with direct or explicit instruction to facilitate teachers and their e-textile project design process (Kirschner et al., 2006).

Teachers who lack sufficient prior knowledge about e-textile practices are likely to suffer and face problems during the training program. For that reason, at the initial stages of the training program, science teachers should be supported with fully guided instruction, but the degree of the instruction should be lowered and get to the minimally guided instruction at the end. The reason to decrease the level of assistance is to prevent teachers being dependable to other knowledge sources and help them construct their own e-textile learning in connection with prior experiences. As teachers engage in sewing with conductive thread and are exposed to different circuit components, they would get used to e-textile materials and design of e-textile projects. Their need for support would naturally decrease and they would not need fully guided instruction anymore.

Consequently, explicit instruction would be a more suitable instructional strategy when teacher participants are novice in e-textile projects in teacher training program. However, the benefits of explicit instructions would begin to recede as teachers get e-textile experiences and get used to materials. That is why, it would be more beneficial and effective to recede the level of guidance during the training program.

5.4.8 Materials and tools

The current study used a collection of wearable and non-wearable materials along with supportive and useful tools. E-textiles are the crux of the materials composed of electronics that can be embedded or sewed into soft textile materials (fabric, germen, felt, etc.) with conductive thread. These materials allowed teachers to design and sew e-textile projects using their STEAM knowledge and experiences. The versatility of materials gave teachers opportunities to showcase their functional and artistic skills in different e-textile designs.

List of design principles for STEAM training camp

- Structure of the STEAM activities

    - Activity content
    - Activity scenario
    - Circuit diagram
    - Design thinking stages
- Organization
    - Safety precautions
    - Camp setting
    - Camp duration
    - Food and beverages
- Instructional strategies
    - Art
    - Creativity
    - Scaffolding
    - Group forming
    - Wearable e-textile technologies
- Subject knowledge
    - STEAM
    - Sewing
    - Circuitry
- Interaction
    - Communication and collaboration between stakeholders
    - Interdisciplinary collaboration in the development of STEAM activities
    - Collaboration within and between groups
- Assessment tools for STEAM learning and understanding
- Issues and challenges
- Materials and tools

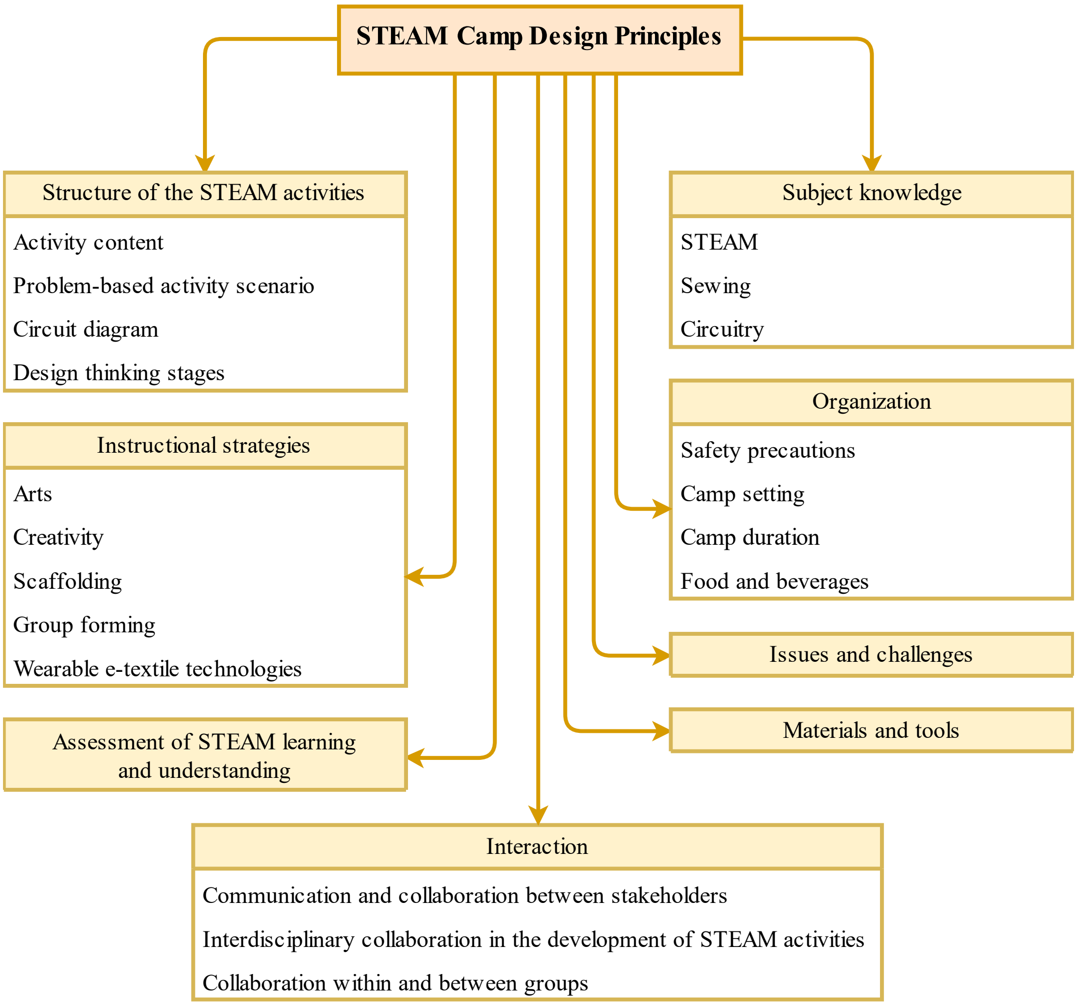

Figure 5.1. Concept network of the STEAM camp design principles

5.4.9 Camp Design Guidelines

Design guidelines described here are composed of two interdependent stages: design stage and the implementation stage. Each of the steps offers a set of suggestions and instructions that should be considered by designers and developers during the design and implementation phase of the camp.

5.4.10 Design phase

- The type of target group should be clearly defined. It is suggested that the camp participants are from different disciplines, especially science, arts, and technology.
- The learning objectives of the middle school level should be considered while preparing STEAM activities.
- STEAM activities should be woven around a problem-based or interest-driven design, not an arbitrary plan. A problem scenario is advised to represent a real problem prevailing in the world or a part of society/group.
- The design to be crafted should resonate with the participants' culture and everyday surroundings.
- Collaboration and joint effort of designers and developers from various subject expertise are suggested for the design of the activities.
- A detailed camp curriculum should be formed in a way that delineates the activities, actions, and plans to be conducted throughout the camp.
- A variety of crafting and textile materials should be supplied in order to encourage using aesthetic and creative skills.
- It is suggested that the camp curriculum consists of various sorts of sewable technologies.
- In the preparation of STEAM activities, structured design is recommended for the participants with no previous e-textile experiences.
- STEAM activities should be designed and organized from simple to complex, and the difficulty level of the activities and its content should be adjusted to the participants' levels and understandings.
- The circuit diagram must be attached to the related activity form.
- Additional sewable technologies should be available in case of an accident and multifunctional devices.

- A large venue with pieces of furniture like chairs and round tables and facilities like internet connection and electricity is recommended for the camp place.
- It could be better to invite one or more speakers who are experts or experienced in art, fashion, design to introduce participants to the crossroads of art, fashion, and design.

5.4.11 Implementation phase

- The camp should start with an introduction section where participants introduce themselves.
- A small-scale training program is recommended at the beginning of the camp in which participants are introduced with activity materials, specifically wearable e-textile technologies, sewing with conductive thread, and Arduino platform.
- There could be a quick demonstration of different project designs that have been previously designed using sewable technologies.
- A group of people with necessary knowledge and experiences about wearable e-textile technologies should support groups in the project design process.
- Groups should be given autonomy and freedom over the project design and use of crafting and textile materials.
- A faded scaffolding technique is recommended while guiding and helping groups during the project design.
- A group composed of at least two or at most three members would be more efficient and productive.
- It is better to avoid forming male or female-dominated groups. Equal gender distribution should be established among groups.
- Facilitators should motivate and drive each of teacher in the group to learn necessary e-textile skills and abilities so that they could be able to transfer those learnings in their classroom.

- Communication and collaboration between and within groups should be encouraged by facilitators.
- Groups should be guided and encouraged to decorate their design
- The most challenging parts of the camp would be to construct a functioning circuit and sew with conductive thread.
- Groups should be encouraged to design their projects following the design thinking stages.
- At least a five-minutes break should be given between activities.
- Beverages and snakes could be offered during the camp.

5.5 The implications of the findings

In the contexts of e-textile technologies and STEAM education, this study has important implications for a better understanding and exploration of design, development, implementation, and integration of hands-on problem-based STEAM activities in or out of science classroom. The study findings are very instructive and beneficial for teachers, researchers, policymakers, school administrators, and even parents. First, this study provided a set of reliable and verified STEAM activities, along with a step-by-step guideline of how to implement them in any institution. Second, the study findings are valuable and comprehensive because it came from teachers of public schools from more than fifteen provinces. Third, the study findings including the distilled design principles that could be very instructive and informative for the individuals planning to either conduct STEAM camp or develop STEAM-like activities in different educational contexts. Fourth, the activities designed in this study could help teachers of various disciplines learn necessary knowledge and skills about e-textile practices and, in turn, transfer those experiences into their classes. Sixth, the study findings provided fruitful information about the importance and necessity of interdisciplinary collaboration between teachers from different subjects for the preparation and implementation of STEAM activities.

5.6 Limitations of the study and recommendations for future research studies

The way this research is being carried out and its findings could be extended in further studies following the recommendations as follows. First, the prepared STEAM activities were implemented and tested by samples of middle school science teachers only. Further studies, however, are required to investigate in detail the application of these activities by mixed groups of teachers from different fields like mathematics, science, visual arts, technology and design, and so on. Additionally, these activities could be used and tested in different samples of students from middle school level to high school and college level. Second, this study put more of its efforts into understanding and exploring STEAM activities out of school space and equipping science teachers with the knowledge and skills related to wearable e-textile technologies and its usage in the context of education. The follow-up studies are needed to examine the implementation of these hands-on activities in school space and to substantiate the study findings of teachers' perceived ability to transfer activity experiences into the classroom. Third, the current research resulted in a series of design principles about the design and application of STEAM activities. The researchers in their future studies could develop hands-on problem-based STEAM-like activities based on the proposed principles and test those principles in terms of its effectiveness and deficiency. Forth, the study showed that interdisciplinary activities produced by teachers in collaboration and coordination with teachers of other subjects ought to be better and more successful than the ones developed in isolation of other subjects. The researchers could test this finding in a quasi-experimental study in which two groups of teachers, group 1 (teachers from the same field) and group 2 (teachers from the different fields), independently develop a couple of STEAM activities. Then, the researchers could compare these activities for their effects on a bunch of variables such as learning outcome, motivation, engagement, participation, creativity, and STEAM attitude.

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APPENDICES

A. Interview Schedule

Araştırma Soruları:

- Giyilebilir teknolojiler temel alınarak hazırlanan Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri eğitim programının tasarım ilkeleri nelerdir?
- Ortaokul çocuklarına yönelik Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerini destekleyen giyilebilir teknolojilerin tasarım, geliştirme ve kullanılabilirlik sorunları nelerdir?
- Fen bilimleri öğretmenler Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri kampı sonuçlarını kendi derslerine ne derece uygulayabilir?

Tarih ve Saat : ____________________	Yer : ____________________
	Görüşülen Kişiler :(1) ____________________
Görüşmeci : ____________________	:(2) ____________________
	:(3) ____________________
	:(4) ____________________

GİRİŞ

Merhaba, ben Mustafa Şat. Orta Doğu Teknik Üniversitesi Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü'nde doktora öğrencisiyim. Yürütmekte olduğum doktora tezi çalışması kapsamında, Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri odaklı giyilebilir teknolojilerin eğitimde kullanımı ile ilgili bir araştırma yapmaktayım ve sizinle kampı sürecinde tasarlamış olduğunuz Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinlikleri ve bu etkinliklerde yaşamış olduğunuz deneyimler hakkında konuşmak istiyorum.

Bu görüşmede amacım, giyilebilir teknolojiler kullanılarak tasarlanan Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri odaklı etkinliklerin ortaokul doğru ve etkin bir şekilde kullanılabilmesi için öğretmenlerin bunu nasıl tasarlaması gerektiğini, bu etkinliklerin tasarlanmasında izlenilmesi gereken tasarım stratejilerinin neler olduğunu ve bu etkinlikleri tasarlarken hangi karakteristik özelliklerin göz önünde bulundurulması gerektiğini ortaya çıkarmaktır. Bu çalışmanın diğer bir amacı ise basit elektrik devreleri ve kavramlarını öğretmek için tasarlanan Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinin olumlu yönlerini, olumsuz yönlerini ve karşılaşılan problemleri öğretmenlerin deneyimleriyle ortaya çıkarmaktır. Bir diğer amaç ise giyilebilir teknolojiler temel alınarak hazırlanan bir Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri eğitim programının sahip olması gereken tasarım ilkelerinin neler olduğunu bütün boyutları ile belirlemektir. Öğretmenlerin Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerini tasarlama sürecinde önemli bir rol oynadıklarını ve bu etkinlikleri tüm boyutları ile değerlendirebildiğini düşündüğüm için onlarla görüşme yapıyorum.

Bu araştırmada ortaya çıkacak sonuçların, giyilebilir teknolojiler ile birlikte sanat ve tasarım araçlarını kullanarak Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri odaklı etkinlikler tasarlayacak öğretmenlere tasarım sürecinde büyük katkılar sunacaktır. Bu nedenle sizin, Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinlikleri ile ilgili deneyimlerinizi ve düşüncelerinizi öğrenmek istiyorum. Bu çalışmaya katılmayı kabul ettiğiniz için teşekkür ediyorum.

Görüşme sürecinde söyleyeceklerinizin tamamı gizli tutulacak ve yalnızca bu araştırma amacı ile kullanılacaktır. Ayrıca, araştırma sonuçlarını yazarken, görüşülen bireylerin isimlerini kesinlikle rapora yansıtılmayacak, bunun yerine takma isimler kullanılacaktır. İzin verirseniz görüşme boyunca gerçekleşen konuşmaların yazıya dökülmesini kolaylaştırmak amacı ile ses kaydı yapmak istiyorum. Bu ses kaydı, yazıya döküldükten hemen sonra silinecektir.

Görüşmeye başlamadan önce, gönüllü katılım formunu okuyarak imzalamanız gerekmektedir. Bu form, yürütülmekte olan çalışma hakkında genel bilgiler vermekle birlikte, çalışmaya gönüllü olarak katıldığınızı gösteren resmi bir belge niteliğindedir.

Görüşme, yaklaşık olarak 1 saat sürecektir ve genel olarak kişisel rahatsızlık verecek soruları içermemektedir. Ancak, katılım sırasında sorulardan ya da başka bir nedenden ötürü kendinizi rahatsız hissederseniz görüşmeyi yarıda bırakıp çıkabilirsiniz. Böyle bir durumda araştırmacıya, görüşmeyi bitirmek istediğinizi söylemeniz yeterli olacaktır. Görüşmeye başlamadan önce söylediklerimle ilgili belirtmek istediğiniz bir düşünce ya da sormak istediğiniz bir soru var mı?

İzin verirseniz ses kayıt cihazını açıp, sorulara başlamak istiyorum.

GÖRÜŞME SORULARI

(GS: Görüşme sorusu; AS: Alternatif Soru; S: Sonda Soru)

<u>İÇERİK</u>

GS-1. Burada sizlerle 3 gündür elektrik konularının öğretimi üzerine STEAM temelli etkinlikler gerçekleştirdik. Gerçekleştirilen etkinliklerin içeriği hakkında ne düşünüyorsunuz

AS-1. Bu içeriklerin elektrik kavramlarını öğretmek için uygun olduğunu düşünüyor musunuz?

S-1.1. Uygun ise hangi açılardan uygun? Açıklar mısınız?

S-1.2. Uygun değil ise hangi açılardan uygun değil? Nasıl uygun hale getirilebilir?

AS-2. Eğitim süresince kullanılan Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerin içeriğinin ortaokul düzeyi için uygun olduğunu düşünüyor musunuz?

S-2.1. Uygun ise hangi açılardan uygun? Açıklar mısınız?

S-3.2. Uygun değil ise hangi açılardan uygun değil? Nasıl uygun hale getirilebilir?

AS-3. Sizce etkinliklerin içeriği ve veriliş yöntemi tasarlanan etkinlikler de olduğu gibi mi verilmeli yoksa değiştirilmeli mi? Nedenini açıklar mısınız?

S-3.1. Siz olsaydınız bu içeriği nasıl verirdiniz?

AS-4. Etkinliklerde kullanılan senaryolar ile ilgili düşünceleriniz nelerdir?

S-4.1. Sizce problem durumunu belirten senaryo kullanılmalı mı yoksa kullanılmasına gerek yok mu? Sebebini açıklar mısınız?

S-4.4. Eğer bu etkinlikleri siz tasarlayacak olsaydınız nasıl bir senaryo yazardanız? Örnek bir senaryo söyler misiniz?

AS-5. Etkinliklerde verilen devre şemasının gösterimi ve örnek bir tasarım ile ilgili düşünceleriniz nelerdir?

S-5.1. Sizce elektronik devrelerin birbirine nasıl dikileceğini gösteren dokümanlar (ör. devre şeması, örnek bir tasarım) verilmeli mi? Sebebini açıklar mısınız?

S-5.2. Verilen dokümanlar (ör. devre şeması, örnek bir tasarım) ürününüzü tasarlama sürecinde size nasıl yardımcı oldu ya da ne gibi faydalar sağladı?

AS-6. Etkinliğin nasıl yapılacağı ile ilgili verilen bilgilerin öğrenciler için yeterli olacağını düşünüyor musunuz?

S-6.1. Yeterli değilse neler yapılması gerekir?

S-6.2. Siz olsanız bu bilgileri nasıl verirdiniz?

TASARIM

GS-2. Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerini tasarlamak için izlediğiniz tasarım odaklı düşünme basamakları hakkında neler düşünüyorsunuz?

AS-2.1. Sizce öğrenciler için gerçekleştirilen etkinliklerde bu basamakları takip etmek uygun mu? Nedenini açıklar mısınız?

AS-2.2. Sizce etkinlik tasarımı için bu basamakları takip etmek yeterli mi? Değilse ne tür değişiklikler ya da eklemeler yapılmalı?

GS-3. Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinin tasarımı hakkındaki düşüncelerinizi anlatır mısınız? Örneğin;

AS-3.1. Tasarlanan bu etkinlikler elektrik devreleri ile ilgili kavramları öğretmek için kullanılabilir mi?

S-3.1.1. Sizce bu etkinlikler bu kavramları öğretmek için ne kadar kullanışlı?

S-3.1.2. Bu etkinliklerin daha iyi kullanılması için hangi türde düzenlemeler veya iyileştirmeler yapılması gerekiyor?

AS-3.2 Tasarlanan bu etkinlikler elektrik devreleri ile ilgili kavramları öğretmek için uygulanabilir mi?

S-3.2.1. Bu etkinlikleri kolay ve etkili bir şekilde uygulanabileceğini düşünüyor musunuz? Detaylı açıklar mısınız?

S-3.2.2. Uygulama sırasında ne gibi problemler ile karşılaşılabilir?

AS-3.3 Tasarlanan bu etkinliklerin elektrik devreleri ile ilgili kavramları öğretmek için etkinli olduğunu düşünüyor musunuz?

S-3.3.1. Etkinlikleri yapmak çok fazla zamanınızı aldı mı?

S-3.3.2. Etkinlikleri yaparken çok fazla zorlandınız mı?

S-3.3.3. Etkinlikler çok fazla karmaşık mıydı?

TASARIMSAL PROBLEMLER & ÖNERİLER

GS-4. Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerini tasarlarken karşılaştığınız problemlerden ve sorunlardan bahseder misiniz?

AS-4.1. İçerik ile ilgili ne gibi sıkıntılar yaşadınız?

S-4.1.1. İçerik ortaokul öğrencileri için uygun mu? Değilse nasıl olmalı? Açıklar mısınız?

S-4.1.1. Kullanılan içerik Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri için uygun mu? Değilse nasıl olmalı? Açıklar mısınız?

AS-4.2. Kullanılan malzemeler ile ilgili ne gibi sıkıntılar yaşadınız?

S-4.2.1. Etkinlik için uygun malzemeyi temin etme ile ilgili sıkıntılar?

S-4.2.2. Sensörlerin hassasiyet düzeyleri ile ilgili?

S-4.2.3. Kalitesi ile ilgili?

AS-4.3. Bu problemleri çözmek için neler yaptınız?

S-4.3.1. Ne tür stratejiler kullandınız?

S-4.3.2. Hangi yöntemlere başvurdunuz?

S-4.3.3. Karşılaştığınız problemleri çözmek için kullandığınız stratejiler ve yöntemler ne derece başarılı oldu?

AS-4.4. Sizce bu problemlerin ortaya çıkmasına neden olan sebepler nelerdir?

S-4.4.1. Etkinlik tasarımından kaynaklı sebeplerle ise bunlar nelerdi? Açıklar mısınız?

S-4.4.2. Sanat ve tasarım araçları ile ilgili sebepler is bunlar nelerdi? Açıklar mısınız?

AS-4.5. Saydığınız problemlerin ortaya çıkmaması için bu etkinliklerin nasıl tasarlanması gerekiyor?

S-4.5.1. Siz olsaydınız bu etkinlikleri nasıl tasarlardınız?

<u>YARATICILILK</u>

GS-5. Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinin yaratıcılık üzerindeki etkileri hakkındaki düşüncelerinizi anlatır mısınız?

AS-5.1. Bu etkinliklerin yaratıcılığı ve yaratıcı düşünmeyi geliştirdiğini düşünüyor musunuz? Nedenini açıklar mısınız?

AS-5.2. Bu etkinliklerde sizi yaratıcı düşünmeye ve yaratıcı fikirler üretmeye teşvik eden kısımlar nelerdi? Örnek verebilir misiniz?

AS-5.3. Tasarımınızın özgünlük, estetik ve diğer açılardan daha yaratıcı olması için neler yaptınız? Örnek verebilir misiniz?

AS-5.4. Yaratıcı düşünmeyi ortaya çıkarmak ve geliştirmek için siz bu etkinlikleri nasıl tasarlardınız?

<u>ETKİLEŞİM</u>

GS-6. Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinde ne tür etkileşimlerde bulundunuz? Örneğin;

AS-6.1. Grup arkadaşınız ya da diğer kişiler ile yapmış olduğunuz etkileşimlerden bahseder misiniz?

AS-6.2. Tasarım ile olan etkileşimlerden bahseder misiniz?

AS-6.3. Yaptığınız bu etkileşimlerin işbirlikçi öğrenmeyi geliştirdiğini düşünüyor musunuz?

AS-6.4. Bu etkileşimleri istenilen seviyeye getirmek için sizce bu etkinlikler nasıl tasarlanmalı? Örneğin;

S-6.4.1. Etkinliklerin bu şekilde tasarlanması ve uygulanması yeterli olur mu? Neden?

S-6.4.2. Yetersiz ise etkinliklerde nasıl bir düzenlemeye ya da tasarıma gidilmeli?

S-6.4.3. Bireysel mi yapılmalı yoksa grup şeklinde mi yapılmalı? Grup şeklinde yapılacaksa grupta kaç kişi olmalı?

GS-7. Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinlikleri öğrencilere ne gibi faydalar sağlayabilir?

AS-7.1. Geleneksel eğitimden farklı olarak Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinlikleri neler sağlıyor? Örnek vererek açıklar mısınız?

AS-7.2. Etkinliklerde birden fazla alandaki bilgi ve becerilerin kullanılması elektrik kavramlarını öğrenmede yararlı olacağını düşünüyor musunuz?

ÖLÇME VE DEĞERLEDİRME

GS-8. Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinde öğrencilerin başarıları ve performansları nasıl ölçülmesi ya da değerlendirilmesi gerekir?

AS-8.1. Etkinlikler için hangi ölçütler veya özellikler değerlendirme için kullanılabilir?

AS-8.2. Tasarlanan ürünün kendisi ve etkinlik tasarım süreci değerlendirme için ayrı mı tutulmalı? Nedenini açıklar mısınız?

S-8.2.1. Tasarlanan ürünün değerlendirmesi hangi ölçütlere göre yapılmalı? Bu ölçütlerin değerlendirilmesinde nasıl bir yöntem kullanılmalı?

S-8.2.3. Etkinlik tasarım sürecinin değerlendirilmesi hangi ölçütlere göre yapılmalı? Bu ölçütlerin değerlendirilmesinde nasıl bir yöntem kullanılmalı?

ENTEGRASYON

GS-9. Deneyimlerinizi göz önünde bulundurduğunuzda, sizce giyilebilir teknolojiler temel alınarak hazırlanan bir Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri eğitim programı hangi özelliklere sahip olmalıdır?

AS-9.1 Sizce bir Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri eğitim programı nasıl tasarlanmalıdır?

S-9.1.1. Malzemeler nasıl olmalı?

S-9.1.2. İçerik nasıl olmalı?

S-9.1.3. Tasarım nasıl olmalı?

AS-9.2. Örneğin bir Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri eğitim programı ile ilgili bu söyleyeceklerime ne kadar katılırsınız?

S-9.2.1. Ergonomik olması

S-9.2.2. Yaparak ve keşfederek öğrenmeyi desteklemesi

S-9.2.3. Bireyselleştirilmiş öğrenmeyi ya da bireysel farklılıkları desteklemesi

S-9.2.4. Demokratik bir öğrenme ortamı sağlaması

S-9.2.5. Mühendislik tasarım sürecine ve tasarım odaklı düşünme odaklanması

S-9.2.6. Problemleri çözme becerisi kazandırması

S-9.2.7. İşbirlikçi öğrenmeyi desteklemesi

S-9.2.8. Farklı alanlardaki bilgi, beceri ve davranışları kullanmayı desteklemesi

AS-9.3. Bunların dışındaki özellikler nelerdir? Bahseder misiniz?

<u>AKTARIM</u>

GS-10. Kampta yapmış olduğunuz etkinlikleri derslerinizde ne kadar uygulayabilirsiniz? Detaylı açıklar mısınız?

GS-11. Kampta öğrendiğiniz bilgi ve becerileri derslerinizde ne kadar aktarabilirsiniz? Detaylı açıklar mısınız?

<u>SANAT</u>

GS-12. Etkinliklerdeki sanat boyutu hakkında neler düşünüyorsunuz? Örneğin;

AS-12.1. Etkinliklerinizde sanat boyutunu katmak için neler yaptınız?

AS-12.2. Etkinliklerin bu şekilde tasarlanması sanatsal becerileri kullanmayı ve geliştirmeyi ne kadar sağlıyor? Öğrenci açısından?

AS-12-3. Etkinliklerde ne tür değişiklikler yapılırsa sanatsal beceriler daha çok kullanılır veya daha çok gelişir?

B. Camp Pre-Evaluation Form

DEMOGRAFİK BİLGİLER

KİŞİSEL BİLGİLER

Adı:		Soyadı:	
Doğum Tarihi		Cinsiyeti:	○ Erkek ○ Kadın

İLETİŞİM BİLGİLERİ

Telefon (Cep):		E-Posta Adresi:	

MESLEK BİLGİLERİ

Çalıştığı Kurum:		Görevi/Ünvanı:	
Çalışma Süresi:			

EĞİTİM BİLGİLERİ

Üniversite (Lisans):			Bölüm/Program:	
Üniversite (Y. Lisans):			Bölüm/Program:	
Lisans Mezuniyet Yılı:			Y. Lisans Mezuniyet Yılı:	
Arduino Bilgi Seviyeniz	○ Hiç Yok	○ Çok Az	○ Orta	○ İyi ○ Çok İyi

Aşağıdaki cümleleri dikkatlice okuyarak sizin için en uygun yanıtı işaretleyiniz.

	Kesinlikle Katılmıyorum	Katılmıyorum	Fikrim Yok	Katılıyorum	Kesinlikle Katılıyorum
1. Her ne kadar planlı olmasa da, öğretim programımda disiplinlerarası yaklaşımın bazı özelliklerine yer veririm.					
2. Dersime öğrencileri hazırlamak için, diğer disiplinlerden materyalleri öğretime kasıtlı ve amaçlı olarak dâhil ederim.					
3. Disiplinlerarası öğretim programı öğrencilerin öğrenmelerini iyileştirir.					
4. Mesleki gelişim eğitimleri disiplinlerarası yaklaşımı sınıfımda kullanmak için beni hazırlamıştır.					
5. Öğretim programı değişikliklerini sınıfımda uygulamak beni rahatsız hissettirir.					
6. Disiplinlerarası öğretim programının temel kavramları üzerine yapılan eğitimlere katılmaya gönüllüyüm.					
7. Diğer disiplinlerden öğretmenler ile çalışmayı zor bulurum					
8. Mevcut öğretim programı yeni fikirlerin uygulanmasını zorlaştırmaktadır.					
9. Kaynak yetersizlikleri (para ve zaman gibi) yeni yaklaşımların uygulanmasını zorlaştırmaktadır.					
10. Disiplinlerarası program, başarılı olamayacak bir başka eğitim reformundan ibarettir.					
11. Diğer disiplinlerin öğretmenleri benim alanımı kendilerininkinden daha az değerli gördüklerinden disiplinlerarası yaklaşımı uygulamada istekli değillerdir.					
12. Benim öğrettiğim disiplin, diğer disiplinler ile karşılaştırıldığında öğrenciler için daha önemlidir.					
13. Disiplinlerarası yaklaşım, konu alanımın öğretimi için önemli olan ders saat süresini boşa harcar.					

14. Disiplinlerarası program mevcut öğretim programımı olumlu yönde geliştirir.					
15. Disiplinlerarası öğretim programı okulumun öğrenme amaçlarının gerçekleştirilmesini destekler.					
16. Mevcut öğretim programı öğrenciler için bütüncül (holistik) bir öğrenme deneyimini vurgular.					

Aşağıdaki soruları dikkatlice okuyarak cevaplayınız?

1. Bu kampa katılmanıza sebep olan nedenler nelerdir? Kamptan beklentileriniz nelerdir?

…………………………………………………………………………………
…………..…………………………………………………………………………

2. Bu kamp sonrası benzer etkinliği okulunuzda gerçekleştirmek konusunda planlarınız var mı?

…………………………………………………………………………………
…………..…………………………………………………………………………

C. Camp Post-Evaluation Form

DEMOGRAFİK BİLGİLER

KİŞİSEL BİLGİLER

Adı:		Soyadı:	
Doğum Tarihi		Cinsiyeti:	○ Erkek ○ Kadın

İLETİŞİM BİLGİLERİ

Telefon (Cep):		E-Posta Adresi:	

MESLEK BİLGİLERİ

Çalıştığı Kurum:		Görevi/Ünvanı:	
Çalışma Süresi:			

EĞİTİM BİLGİLERİ

Üniversite (Lisans):		Bölüm/Program:	
Üniversite (Y. Lisans):		Bölüm/Program:	
Lisans Mezuniyet Yılı:		Y. Lisans Mezuniyet Yılı:	

Aşağıdaki cümleleri dikkatlice okuyarak bu ifadelere katılma ve katılmama durumunuzu 1 - 6 (1: Hiç - 6: Çok Fazla) arasında değişen skala üzerinde belirtiniz?

	Hiç					Çok Fazla
	1	2	3	4	5	6	7
Kampın genel olarak yararlı geçtiğini düşünüyorum.							
Kampın Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri alanlarındaki bilgi ve becerilerimi artırdığını düşünüyorum.							
Kampın bana birçok açıdan fayda sağladığını düşünüyorum.							
Kampın öğretmenlik mesleğime katkı sağladığını düşünüyorum.							
Kampın elektrik kavramlarını öğrenmemde bana fayda sağladığını düşünüyorum.							
Kampın sanatsal becerilerimi kullanmamda ve geliştirmemde bana katkı sağladığını düşünüyorum.							
Kamp sayesinde tasarım odaklı düşünme basamaklarını izleyerek bir ürün tasarlamayı ve geliştirmeyi öğrendim.							
Kamptaki etkinliklerin öğrencilerin ince kas becerilerini geliştireceğini düşünüyorum.							
Kamptaki etkinlikleri severek yaptım.							
Kamp benim için sıkıcı geçti.							
Kamp süresince eğlenceli zaman geçirdim.							
Benzer kampların sıklıkla yapılması gerektiğini düşünüyorum.							
Kamptaki etkinlikleri istemeyerek yaptım.							
Bu veya buna benzer kamplara tekrar katılmak isterim.							
Bu kampa katılmayı meslektaşlarıma tavsiye etmem.							
Benzer kampların <u>*okul içi*</u> etkinlik olarak yapılması gerektiğini düşünüyorum.							
Kamptaki etkinliklerin zor olduğunu düşünüyorum.							
Kamptaki etkinlikleri yapmak eğlenceliydi.							
Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri kampının iyi organize edildiğini düşünüyorum.							

Kamp Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerine karşı ilgi ve motivasyonumu arttırdı.							
Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri kampı beklentilerimi karşılamadı.							
Etkinliklere ayrılan sürelerin yeterli olduğunu düşünüyorum.							
Etkinlikleri tamamlamam çok fazla zamanımı aldı.							
Etkinlikleri yaparken zamanın hızlı geçtiğini düşünüyorum.							
Kamptaki sanat ve tasarım ile ilgili malzemelerin etkinlikleri tasarlamak için yeterli *sayıda* olduğunu düşünüyorum.							
Kampta etkinlik tasarımları için ihtiyaç duyduğum malzemeleri bulmakta zorlandım.							
Kamptaki giyilebilir teknoloji malzemelerinin yeterli olduğunu düşünüyorum.							
Kampta etkinlik tasarımları için kullandığım malzemelerin kalitesi kötüydü.							
Kamptaki sanat ve tasarım ile ilgili malzemelerin etkinlikleri tasarlamak için yeterli *çeşitliliğe* sahip olduğunu düşünüyorum.							
Kampta etkinlik tasarımları için verilen malzemeler kullanışsızdı.							
Kamptaki giyilebilir teknoloji malzemelerinin yeterli *çeşitliliğe* sahip olduğunu düşünüyorum.							
Kampta öğrendiklerimi kendi okulumda uygulayabileceğimi düşünüyorum.							
Kampta öğrendiğim bilgi ve becerileri öğrencilerime aktarabilecek kadar kendimi yeterli görüyorum.							
Derslerimde elektrik kavramlarını öğretmek için giyilebilir teknolojilerden faydalanabilirim.							
Elektrik kavramlarını öğretmek için Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinin kullanılabileceğini düşünüyorum.							
Kampta edindiğim bilgiler doğrultusunda öğrencilerimle yeni projeler yapmayı planlıyorum.							
Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinin müfredatta yer alması gerektiğini düşünüyorum.							

Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinde öğrendiğim bilgi ve beceriler sayesinde giyilebilir teknolojiler kullanarak benzer etkinlikleri tasarlayabileceğimi düşünüyorum.							
Kampta öğrendiklerim sayesinde giyilebilir teknolojileri farklı alanlarda kullanabileceğimi düşünüyorum.							
Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinde sanat boyutunu tasarımlarıma yeteri kadar aktarabildiğimi düşünüyorum.							
Kamp sırasında zorlandığım anlarda yardım edecek birisini ya da birilerini hemen bulabildiğimi düşünüyorum.							
Kampta verilen desteğin yeterli seviyede olduğunu düşünüyorum.							
Kampta destek veren kişilerin yeterli bilgi ve beceriye sahip olduğunu düşünüyorum.							
Kampta verilen destekler ve yardımlar sayesinde etkinlikleri yapabildiğimi düşünüyorum.							
Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinin disiplinlerarası öğrenmeye olanak sağladığını düşünüyorum.							
Kamptaki etkinliklerin beş alandaki (Fen, Teknoloji, Mühendislik, Sanat, Matematik) bilgi ve becerileri kullanmayı teşvik ettiğini düşünüyorum.							
Kamptaki etkinlikler sayesinde beş alandaki (Fen, Teknoloji, Mühendislik, Sanat, Matematik) bilgi ve becerilerimi geliştirdiğimi düşünüyorum.							
Kampta edindiğim becerilerimi geliştirmeyi planlıyorum.							
Kampta edindiğim bilgiler doğrultusunda yeni projeler geliştirmeyi planlıyorum.							
Kampta elektrik kavramları ile ilgili birçok şey öğrendiğimi düşünüyorum.							
Kamp sayesinde Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinin nasıl tasarlanması gerektiğine dair fikir sahibi oldum.							

Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinin yaratıcı becerilerimi kullanmam için beni teşvik ettiğini düşünüyorum.							
Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerinin yaratıcı becerilerimi geliştirdiğini düşünüyorum.							
Kampta Arduino ile kodlamanın nasıl yapıldığını öğrendim.							
Aktiviteler için verilen yönergeler ve açıklamalar açık ve anlaşılırdı.							
Aktiviteler için verilen yönergeler ve açıklamaları anlamakta zorluk çekmedim.							
Aktiviteler için verilen yönergeler ve açıklamaları uygulamakta zorluk çekmedim.							
Kamptaki etkinlikleri yaparken zorlanmadığımı düşünüyorum.							
Kamptaki etkinliklerin anlaşılmayacak derecede karmaşık olduğunu düşünüyorum.							
Etkinliklerin yapılmasının ve uygulanmasının kolay olduğunu düşünüyorum.							
Öğrencilerin Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri etkinliklerini yaparken zorlanmayacağını düşünüyorum.							
Kamp yerindeki teknolojik altyapı yeterliydi.							
Etkinliklerin olduğu yer havasızdı.							
Yemekler bol ve lezzetliydi.							
Kampın yapıldığı yere ulaşım zordu.							

Kampta görev alan ve kamp süresince destek sağlayan öğretim elemanları ve diğer kişilere ile ilgili düşüncelerinizi 1 - 6 (1: Hiç - 6: Çok Fazla) arasında değişen skala üzerinde belirtiniz?

		Hiç						Çok Fazla
		1	2	3	4	5	6	7
Akademik olarak:								
	Alanında uzman							
	Başarılı							
	Bilgili							
Kişisel Olarak:								
	Cana yakın							
	Özverili							
	İlgili							
	Rahatlatıcı							
	Eğlence Verici							
	Güvenilir							

Aşağıdaki soruları dikkatlice okuyarak cevaplayınız?

1. Kampta en çok beğendiğiniz etkinlikler ya da kısımlar nelerdi?
………………………………………………………………………………………… …………………………………………………………………………………………
2. Kamp beklentileriniz nelerdi ve kamp bu beklentilerinizi ne derece sağladı?

…………………………………………………………………………………………… ……………………………………………………………………………………………
3. Kampta gördüğünüz eksiklikler ve problemler nelerdi?
…………………………………………………………………………………………… ……………………………………………………………………………………………
4. Kampı geliştirmek için önerileriniz nelerdir?
…………………………………………………………………………………………… ……………………………………………………………………………………………
5. Bunların dışında eklemek istediğiniz başka şeyler nelerdir?
…………………………………………………………………………………………… ……………………………………………………………………………………………
6. Giyilebilir teknolojilerin Fen ve Teknoloji Eğitiminde özellikle hangi konularda kullanılabileceğini düşünüyorsunuz?
…………………………………………………………………………………………… ……………………………………………………………………………………………
7. Kampta en çok hangi görevleri anlamakta/uygulamakta zorlandınız? Sebepleri nelerdir?
…………………………………………………………………………………………… ……………………………………………………………………………………………
8. Etkinliklerin bireysel ya da grup şeklinde yapılması hakkında ne düşünüyorsunu
…………………………………………………………………………………………… ……………………………………………………………………………………………
9. Etkinliklerin içeriği ve çeşitliliği hakkında ne düşünüyorsunuz?
…………………………………………………………………………………………… ……………………………………………………………………………………………

D. Activity Evaluation Form

Bu değerlendirme formu yapmış ve bitirmiş olduğunuz etkinlik ile ilgili deneyimlerinizi, düşüncelerinizi ve önerilerinizi almak için hazırlanmıştır. Lütfen soruları eksiksiz bir şekilde cevaplayınız.

1. **Etkinliği yaparken ne gibi problemlerle karşılaştınız?** *(taslak çiziminde çizilen tasarımı prototip tasarıma aktarma, malzeme, içerik, tasarım vb. konularla ilgili)*

……………………………………………………………………………………

……………………………………………………………………………………

2. **Elektrik devreleri ile ilgili kavramları öğretmek için tasarlanan bu etkinlik hakkındaki düşünceleriniz nelerdir?** *(elektrik devreleri ile ilgili kavramları öğretmek için kullanılabilirliği, ortaokul düzeyi için uygunluğu, malzeme, içerik ve tasarım açısından bakabilirsiniz)*

……………………………………………………………………………………

……………………………………………………………………………………

3. **Sizce bu etkinlik nasıl olmalıydı ya da nasıl tasarlanmalıydı?** *(Malzeme, içerik, tasarım ve süreç açısından bakabilirsiniz)*

……………………………………………………………………………………

……………………………………………………………………………………

4. **Bu etkinlik sonunda elde ettiğiniz bilgi, beceri ve deneyimlerden hangilerini kendi derslerinizde uygulayabileceğinizi düşünüyorsunuz?**

……………………………………………………………………………………

……………………………………………………………………………………

5. **Etkinlik tasarımına sanat boyutunu katmak için neler yaptınız?** *(renk tonları arasındaki uyum ve bütünlük, tasarımdaki görsel zenginlik ve sadelik, tasarım parçaları arasındaki simetrik denge ve tasarımın estetik olması vb. konularla ilgili)*

……………………………………………………………………………………

……………………………………………………………………………………

6. **Bu etkinliğin öğrencilerin hangi alandaki bilgi ve becerilerini kullanmayı ve geliştirmeyi destekliyor?** *(Fen, teknoloji, mühendislik, sanat, matematik, yaratıcılık, problem çözme, ince kas becerisi, yaparak ve keşfederek öğrenme, işbirlikçi öğrenme, vb. alanlar ya da kavramlar gibi)*

……………………………………………………………………………………

……………………………………………………………………………………

E. Transfer of Camp Learning and Experience Form

Öğrendiklerini Uygulama ve Aktarma

Bu formun amacı MODAK kampında öğrenmiş olduğunuz bilgi ve becerileri nerede ve nasıl uyguladığınızı ve aktardığınızı öğrenmektir. Lütfen soruları eksiksiz bir şekilde cevaplayınız.

Adı ve Soyadı:

1. **MODAK ve benzeri eğitim verdiniz mi? Ya da MODAK kampında yapmış olduğunuz etkinlikleri uyguladınız mı?** (Eğer cevabınız EVET ise aşağıdaki soruları cevaplayınız)

…………………………………………………………………………………
…………………………………………………………………………………

2. **Bu eğitimi ya da uygulamayı öğretmenlere mi yoksa öğrencilere mi verdiniz?** *(Lütfen detaylı açıklayınız)*

…………………………………………………………………………………
…………………………………………………………………………………

3. **Verdiğiniz eğitim ya da yaptığınız uygulama okulda kulüp tarzı mıydı yoksa kamp, okul dışı etkinlik, proje, bilimsel çalışma vs. tarzı mıydı?** *(Lütfen detaylı açıklayınız)*

…………………………………………………………………………………
…………………………………………………………………………………

4. **MODAK Kampında öğrendikleriniz işinize ne kadar yaradı?** *(Lütfen detaylı açıklayınız)*

…………………………………………………………………………………
…………………………………………………………………………………

5. **Yaptığınız eğitimlerde ya da uygulamalarda MODAK kampında öğrendikleriniz üzerinde ne tür değişiklikler ve revizyonlar yaptınız?**

…………………………………………………………………………………
…………………………………………………………………………………

F. Permission of Metu Ethic Committee

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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Sayı: 28620816 /360

06 Haziran 2018

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof. Dr. Kürşat ÇAĞILTAY

Danışmanlığını yaptığınız doktora öğrencisi Mustafa ŞAT'ın **"Steam-Powered Activities For Middle School Science Teachers: A Design and Development Research"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2018-FEN-103** protokol numarası ile **08.06.2018 - 30.12.2019** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Ş. Halil TURAN
Başkan V

Prof. Dr. Ayhan SOL
Üye

Prof. Dr. Ayhan Gürbüz DEMİR
Üye

Doç. Dr. Yaşar KONDAKÇI
Üye

Doç. Dr. Zana ÇITAK
Üye

Doç. Dr. Emre SELÇUK
Üye

Dr. Öğr. Üyesi Pınar KAYGAN
Üye

G. Teacher Consent Form

Bu çalışma Prof. Dr. Kürşat Çağıltay danışmanlığında, doktora öğrencisi Mustafa Şat tarafından yürütülmekte olan geliştirme çalışmasıdır. Çalışmanın amacı, giyilebilir teknolojiler kullanılarak tasarlanan Fen, Teknoloji, Mühendislik, Sanat ve Matematik bilimleri odaklı etkinliklerin ortaokul düzeyi için doğru ve etkin bir şekilde kullanılabilmesi için öğretmenlerin bunu nasıl tasarlaması gerektiğini, bu etkinliklerin tasarlanmasında izlenilmesi gereken tasarım stratejilerinin neler olduğunu ve bu etkinlikleri tasarlarken hangi karakteristik özelliklerin göz önünde bulundurulması gerektiğini ortaya çıkarmaktır. Çalışmaya katılım tamamıyla gönüllülük esasına dayanmaktadır. Görüşme süresince, sizden kimlik belirleyici hiçbir bilgi istenmeyecektir. Cevaplarınız tamamıyla gizli tutulacak ve sadece araştırmacı tarafından değerlendirilecektir. Elde edilecek bilgiler bilimsel yayımlarda kullanılacaktır.

Görüşme, genel olarak kişisel rahatsızlık verecek sorular içermemektedir. Ancak, katılım sırasında sorulardan ya da başka bir nedenden ötürü kendinizi rahatsız hissederseniz cevaplama işini yarıda bırakıp çıkabilirsiniz. Böyle bir durumda araştırmacıya, görüşmeyi bitirmek istediğinizi söylemeniz yeterli olacaktır. Görüşme sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır. Çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için Orta Doğu Teknik Üniversitesi Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü öğretim üyelerinden Prof. Dr. Kürşat Çağıltay (Oda: EF-C 19; Tel: 210 3683) ya da doktora öğrencisi Mustafa Şat ile iletişim kurabilirsiniz.

Bu çalışmaya tamamen gönüllü olarak katılıyorum ve istediğim zaman yarıda kesip çıkabileceğimi biliyorum. Verdiğim bilgilerin bilimsel amaçlı yayımlarda kullanılmasını kabul ediyorum. (Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

Ad Soyad: Tarih: ----/----/----- İmza:

Alınan Ders:

H. E-Textile Supported Steam-Based Activities

FEN-TEKNOLOJİ-MÜHENDİSLİK-SANAT-MATEMATİK
ETKİNLİĞİ- 1

LED Kullanarak Rozet Dikme ve Giysi Tasarımı

Program Adı:	Giyilebilir Teknolojiler
KONU:	Temel Elektrik Devreleri ve Kavramları
Hedef Kitle (Yaş Grubu):	Ortaokul Öğrencileri (10 – 14 Yaş Aralığı)
Süre:	1 – 2 SAAT

KAZANIMLAR	Etkinlik yoluyla ulaşılması amaçlanan kazanımlar aşağıda belirtilmiştir

Bu etkinliğin amacı giyilebilir teknolojiler ile birlikte sanat ve tasarım araçlarını kullanarak;

- Ortaokul öğrencilerine temel elektrik kavramlarını öğretmek.
- Özgün ve yaratıcı bir ürün tasarlamak.
- Öğrencilerin elektrik devreleri konusu ile ilgili sahip olduğu bilgi ve beceriler günlük hayatta bir amaca ya da bir problemi çözmeye yönelik kullanması.
- Ortaokul öğrencilerini tasarım odaklı düşünme süreçlerinin içerisine aktif olarak katarak sanat ve tasarım yönünden estetik, özgün ve yaratıcı bir ürün tasarlamalarına olanak tanımak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini kullanarak bir ürün geliştirmelerini sağlamak.

- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini artırıp geliştirmelerine olanak tanımak.

ETKİNLİK SÜRECİ	Tasarım boyunca izlenilmesi gereken süreçler aşağıda belirtilmiştir

- Etkinlik sürecinde tasarlanacak olan ürün verilen "Tasarım Odaklı Düşünme Basamakları" takip edilerek gerçekleştirilir. Her basamakta neler yapılması gerektiği açık bir şekilde belirtilmiştir. Katılımcılar ilgili basamakta yapılması gerekenleri yaptıktan sonra bir sonraki basamağa geçmelidir.
- Etkinlikte kullanılacak malzemeler (giyilebilir teknolojiler ile sanat ve tasarım araçları) aşağıda tablo şeklinde verilmiştir. Ürün tasarımında tabloda verilmeyen farklı sanat ve tasarım araçları da kullanılabilir.
- Tasarımda kullanılacak devre şeması örnek bir tasarım üzerinde aşağıda verilmiştir. Devre şeması üzerinde elektronik devrelerin iletken iplik kullanılarak birbirine nasıl dikilerek bağlanacağı açık bir şekilde gösterilmiştir. Katılımcılar verilen örnek tasarım yerine kendilerinin belirlediği ve kendilerine özgü bir tasarım yapmaları gerekmektedir.

SENARYO	Etkinlik ile ilgili problem durumunu anlatan senaryo

Aşağıda problem durumunu anlatan senaryoyu okuyarak verilen problemi tanımlayınız.

Güneş, Ay ve Dünya Orta Doğu Teknik Üniversitesi'nde okuyan üç lisans öğrencisidir. Üç farklı bölümde okuyan bu üç farklı öğrenciyi bir araya getiren ortak nokta, her üçünün de dünyanın çevresindeki gezegenlere olan merakıdır. Bu üç öğrenci kendileri gibi düşünen ve uzaya karşı ilgileri olan öğrencileri bir araya getirmek için "Kara Delik" adında bir öğrenci grubu kurmak için işe koyulurlar. Uzun bir çalışmadan sonra grubu kurarlar, fakat "Kara Delik" grubunu en iyi yansıtacak ve öğrencilerin dikkatini çekecek bir slogan ve bu slogan ile ilişkili bir grup rozetine ihtiyaçları vardır. Tasarlanacak rozette aşağıdaki özellikler aranmaktadır:

- Tasarlanan ürün ile slogan arasında bir ilişkinin olması.

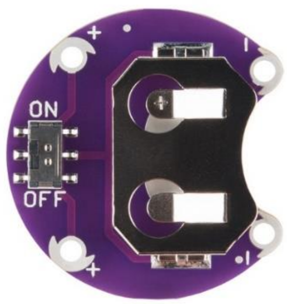
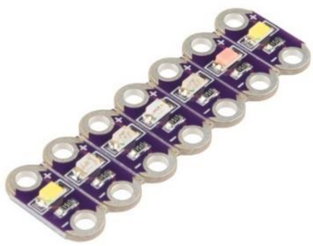
- LED üzerinden geçen voltaj miktarının 3.7-volt üzerinde olmaması.

GÖREV	Problem durumuna yönelik yapılması gereken görevler

“Kara Delik” grubu için ilk önce bir slogan bulmak/üretmek ve daha sonra da bu sloganı belirten ve yansıtan özgün ve yaratıcı bir rozet tasarlamak. Bu görev kapsamında kullanılacak giyilebilir teknolojiler, sanat ve tasarım araçları, taslak çizim formu, uygulanacak devre türü, elektronik devre elemanlarının iletken iplik ile birbirine nasıl dikileceğini gösteren devre şeması ve örnek bir tasarım aşağıda belirtilmiştir.

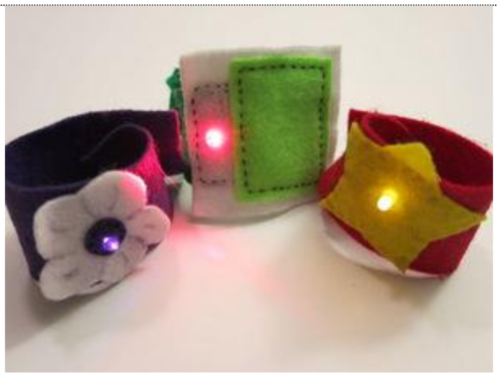
MALZEMELER	Tasarımda kullanılacak malzemeler ile ilgili bilgiler aşağıda verilmiştir

Giyilebilir teknolojiler ile birlikte sanat ve tasarım araçları ürün tasarımı için kullanılacak olan malzemelerdir. Gruplar ürün tasarımı kapsamında sınırlı sayıda giyilebilir teknoloji malzemesi kullanabilirken sanat ve tasarım araçlarını istedikleri sayıda ve miktarda kullanabilmektedir. Sınırlı sayıdaki malzemeler gruplara etkinlikten önce verilecektir. Ayrıca etkinlik ortamında grupların kullanabileceği, aşağıdaki tabloda belirtilmeyen farklı türdeki ortak malzemeler de bulunmaktadır. Kullanılacak olan malzemeler aşağıda belirtilmiştir.

Giyilebilir Teknolojiler	Sanat ve Tasarım Araçları
	
Lilypad Para Pil Yuvası (1 Adet)	Keçe
	
Lilypad LED (1 Adet)	İğne

	
Para Pil (1 Adet)	Normal İplik
	
İletken İplik	Demir Çıt Çıt (2 Adet)

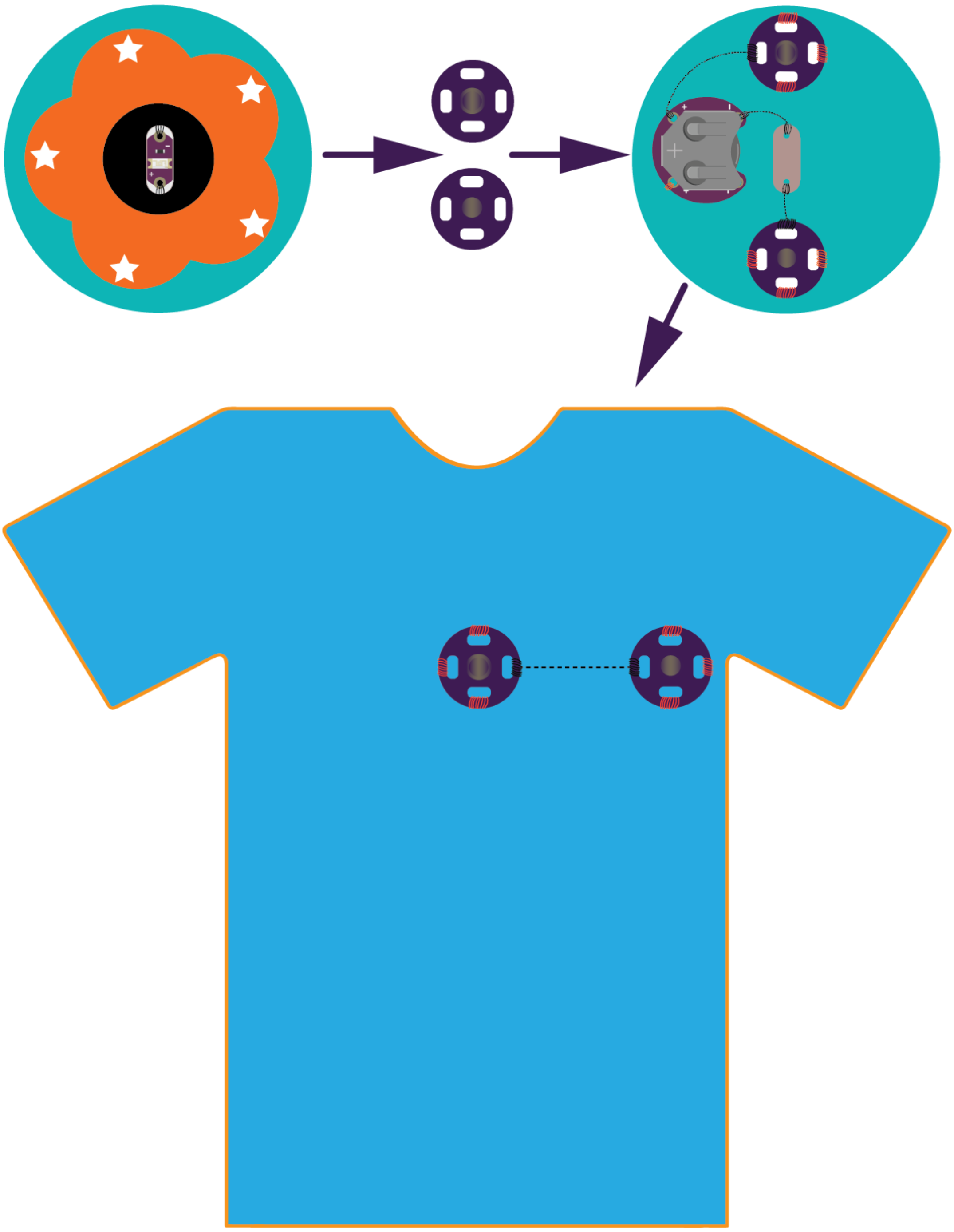
ÖRNEK TASARIMLAR	Aşağıdaki tasarım örnekleri dikilebilir teknolojiler ile birlikte sanat ve tasarım araçları kullanılarak tasarlanmıştır.

	
Bileklik Tasarımı	Emoji Tasarımı

 Şimşek Tasarımı	 Gökkuşağı Tasarımı
 Hayvan Resmi Tasarımı	 Sevgililer Günü Kalp Tasarımı

TASLAK ÇİZİMİ	Tasarlanacak projenin taslak çizimi aşağıda detaylı olarak çizilir

DEVRE ŞEMASI	Devre elemanlarının birbirine nasıl dikilmesi gerektiğini gösteren devre şeması



FEN-TEKNOLOJİ-MÜHENDİSLİK-SANAT-MATEMATİK ETKİNLİĞİ - 2

LED Kullanarak Bileklik Dikme ve Giysi Tasarımı

Program Adı:	Giyilebilir Teknolojiler
KONU:	Temel Elektrik Devreleri ve Kavramları
Hedef Kitle (Yaş Grubu):	Ortaokul Öğrencileri (10 – 14 Yaş Aralığı)
Süre:	1 – 2 SAAT

KAZANIMLAR	Etkinlik yoluyla ulaşılması amaçlanan kazanımlar aşağıda belirtilmiştir

Bu etkinliğin amacı giyilebilir teknolojiler ile birlikte sanat ve tasarım araçlarını kullanarak;

- Ortaokul öğrencilerine temel elektrik kavramlarını öğretmek.
- Özgün ve yaratıcı bir ürün tasarlamak.
- Öğrencilerin elektrik devreleri konusu ile ilgili sahip olduğu bilgi ve beceriler günlük hayatta bir amaca ya da bir problemi çözmeye yönelik kullanması.
- Ortaokul öğrencilerini tasarım odaklı düşünme süreçlerinin içerisine aktif olarak katarak sanat ve tasarım yönünden estetik, özgün ve yaratıcı bir ürün tasarlamalarına olanak tanımak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini kullanarak bir ürün geliştirmelerini sağlamak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini artırıp geliştirmelerine olanak tanımak.

ETKİNLİK SÜRECİ	Tasarım boyunca izlenilmesi gereken süreçler aşağıda belirtilmiştir

- Etkinlik sürecinde tasarlanacak olan ürün verilen “Tasarım Odaklı Düşünme Basamakları” takip edilerek gerçekleştirilir. Her basamakta neler yapılması gerektiği açık bir şekilde belirtilmiştir. Katılımcılar ilgili basamakta yapılması gerekenleri yaptıktan sonra bir sonraki basamağa geçmelidir.
- Etkinlikte kullanılacak malzemeler (giyilebilir teknolojiler ile sanat ve tasarım araçları) aşağıda tablo şeklinde verilmiştir. Ürün tasarımında tabloda verilmeyen farklı sanat ve tasarım araçları da kullanılabilir.
- Tasarımda kullanılacak devre şeması örnek bir tasarım üzerinde aşağıda verilmiştir. Devre şeması üzerinde elektronik devrelerin iletken iplik kullanılarak birbirine nasıl dikilerek bağlanacağı açık bir şekilde gösterilmiştir. Katılımcılar verilen örnek tasarım yerine kendilerinin belirlediği ve kendilerine özgü bir tasarım yapmaları gerekmektedir.

SENARYO	Etkinlik ile ilgili problem durumunu anlatan senaryo

Sema gece geç saatlere kadar ders çalıştığı için sabah geç uyanmıştır. Uyanır uyanmaz hemen yüzünü yıkar ve kahvaltı yapmak için doğruca mutfağa yönelir. Annesi kahvaltının henüz hazır olmadığını söyleyince o da o günkü gazeteye göz atmak ister. Gazetenin ilk sayfasının sağ üst köşesinde kırmızı yazı ile yazılan “Genç Mucitler Modayı Tasarlıyor” başlığı dikkatini çeker. Yazıda 2018 yılının Milli Eğitim Bakanlığı tarafından öğrencilerin yaratıcı becerilerini geliştirmek “Tasarım ve Moda” yılı olarak ilan ettiğine yer verilmiştir. Ayrıca tasarım ve moda yılı kapsamında ülkenin bazı bölgelerinde seçilen pilot okullarda “genç mucitler modayı tasarlıyor” etkinliği yapılacaktır. Sema’nın da modaya karşı ilgisi vardır. Hatta kendince evde bulduğu kumaş parçalarını kullanarak hayvan figürleri diker ve bunları takı kutusunda sakladığı takı malzemeleri ile güzelce süsler. Sema içinden “Keşke bizim okul da pilot okulu olarak seçilse.” diye geçirir. Sema bir gün okulda son derse katılmak üzere sınıfta oturduğu masada yerini alır. Ders hocası ile birlikte sınıfa okul müdürü de gelince bütün öğrenciler çok şaşırır. Okul müdürü okullarının pilot okul seçildiğini söyler. Yoğun bir hazırlık sürecinden sonra etkinlikler sonunda başlamıştı. İlk etkinlikte eldeki malzemeleri etkin ve yaratıcı bir biçimde kullanarak cansız bir mankeni giydirme görevini içermektedir. Bunun için iş bölümü yapıldı ve Sema’ya da mankenin koluna takılacak estetik açıdan zengin ve uygun renk tonlarına sahip bir kol bilekliği tasarlama ve dikme görevi verildi. Fakat etkinliğe az miktarda para ayrıldığı için alınması gereken giyilebilir teknolojilerin sayısında kısıtlamaya gidilmiştir. Ayrılan para ile 3 tane LED, 1 tane pil yuvası ve 1 tane de pil alınabilmiştir. Bu kısıtlamalara rağmen dikilecek bilekliğin belirli bazı özelliklere sahip olması istenmektedir. Bu özelliklerden biri bileklik üzerine dikilecek LED'lerin eşit parlaklıklarda yanmasıdır. Diğer bir özellik ise LED'lerden birinin bozulması ya da yanması halinde diğer LED'lerin bundan etkilenmemesi ve aynı parlaklıkta yanmaya devam etmesidir. Ayrıca takılacak kolun zarar görmemesi için her LED üzerinden geçen voltaj miktarının 3.7 volttan daha az olması gerekmektedir.

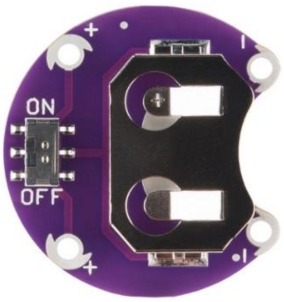
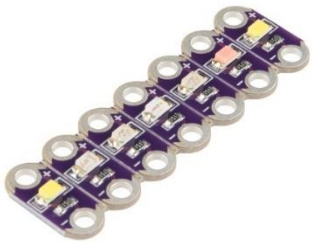
GÖREV	Problem durumuna yönelik yapılması gereken görevler

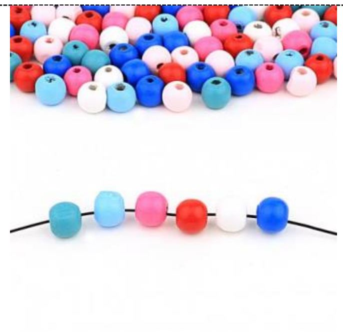
Sema'nın görevini üstlenmek ve bu görev kapsamında belirtilen kısıtlamaları ve tasarımda olması gereken özellikleri göz önünde bulundurarak estetik, özgün ve yaratıcı bir bileklik tasarlamak. Bu görev kapsamında kullanılacak giyilebilir teknolojiler, sanat ve tasarım araçları, taslak çizim formu, elektronik devre elemanlarının iletken iplik ile birbirine nasıl dikileceğini gösteren devre şeması ve örnek bir tasarım aşağıda belirtilmiştir.

MALZEMELER	Tasarımda kullanılacak malzemeler ile ilgili bilgiler aşağıda verilmiştir

Ürün tasarımı için giyilebilir teknolojiler ile birlikte sanat ve tasarım araçları kullanılacaktır. Etkinliğe kısıtlı bir bütçe ayrıldığı için her gruba dikilebilir teknoloji olarak 3 tane Lilypad LED, 1 tane Lilypad para pil yuvası ve 1 tane de para pil verilmiştir. Fakat gruplar istedikleri sayıda ve miktarda sanat ve tasarım araçlarını kullanabilmektedir. Sınırlı sayıdaki malzemeler gruplara etkinlikten önce verilecektir. Ayrıca etkinlik ortamında grupların kullanabileceği, aşağıdaki tabloda belirtilmeyen farklı türdeki ortak malzemeler de bulunmaktadır. Kullanılacak olan malzemeler aşağıda belirtilmiştir.

ÖRNEK TASARIMLAR	Aşağıdaki tasarım örnekleri dikilebilir teknolojiler (1 adet Lilypad Pil Yuvası ve 1 adet Lilypad LED) ile birlikte sanat ve tasarım araçları kullanılarak tasarlanmıştır.

Giyilebilir Teknolojiler	**Sanat ve Tasarım Araçları**
	
Lilypad Para Pil Yuvası (1 Adet)	Keçe
	
Lilypad LED (3 Adet)	İğne
	
Para Pil (1 Adet)	Normal İplik
	
İletken İplik	Demir Çıt Çıt (2 Adet)

	
Dijital Multimetre	Karışık Düğmeler
	
Krokodil Kablo	Karışık Boncuklar

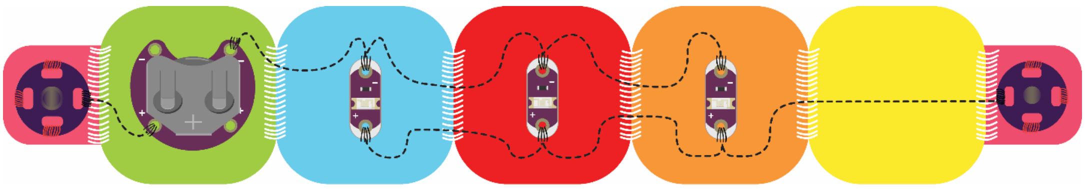
ÖRNEK TASARIMLAR	Aşağıdaki tasarım örnekleri dikilebilir teknolojiler ile birlikte sanat ve tasarım araçları kullanılarak tasarlanmıştır.

	
Göz Maskesi Tasarımı	Batman Maskesi Tasarımı

	
Pizza Parçası Tasarımı	Roket Tasarımı
	
Anahtarlık Tasarımı	Bileklik Tasarımı

TASLAK ÇİZİMİ	Tasarlanacak projenin taslak çizimi aşağıda detaylı olarak çizilir

DEVRE ŞEMASI	Devre elemanlarının birbirine nasıl dikilmesi gerektiğini gösteren devre şeması



FEN-TEKNOLOJİ-MÜHENDİSLİK-SANAT-MATEMATİK ETKİNLİĞİ- 3

LED Kullanarak Kolye Dikme ve Giysi Tasarımı

Program Adı:	Giyilebilir Teknolojiler
KONU:	Temel Elektrik Devreleri ve Kavramları
Hedef Kitle (Yaş Grubu):	Ortaokul Öğrencileri (10 – 14 Yaş Aralığı)
Süre:	1 – 2 SAAT

KAZANIMLAR	Etkinlik yoluyla ulaşılması amaçlanan kazanımlar aşağıda belirtilmiştir

Bu etkinliğin amacı giyilebilir teknolojiler ile birlikte sanat ve tasarım araçlarını kullanarak;

- Ortaokul öğrencilerine temel elektrik kavramlarını öğretmek.
- Özgün ve yaratıcı bir ürün tasarlamak.
- Öğrencilerin elektrik devreleri konusu ile ilgili sahip olduğu bilgi ve beceriler günlük hayatta bir amaca ya da bir problemi çözmeye yönelik kullanması.
- Ortaokul öğrencilerini tasarım odaklı düşünme süreçlerinin içerisine aktif olarak katarak sanat ve tasarım yönünden estetik, özgün ve yaratıcı bir ürün tasarlamalarına olanak tanımak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini kullanarak bir ürün geliştirmelerini sağlamak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini artırıp geliştirmelerine olanak tanımak.

ETKİNLİK SÜRECİ	Tasarım boyunca izlenilmesi gereken süreçler aşağıda belirtilmiştir

- Etkinlik sürecinde tasarlanacak olan ürün verilen “Tasarım Odaklı Düşünme Basamakları” takip edilerek gerçekleştirilir. Her basamakta neler yapılması gerektiği açık bir şekilde belirtilmiştir. Katılımcılar ilgili basamakta yapılması gerekenleri yaptıktan sonra bir sonraki basamağa geçmelidir.
- Etkinlikte kullanılacak malzemeler (giyilebilir teknolojiler ile sanat ve tasarım araçları) aşağıda tablo şeklinde verilmiştir. Ürün tasarımında tabloda verilmeyen farklı sanat ve tasarım araçları da kullanılabilir.
- Tasarımda kullanılacak devre şeması örnek bir tasarım üzerinde aşağıda verilmiştir. Devre şeması üzerinde elektronik devrelerin iletken iplik kullanılarak birbirine nasıl dikilerek bağlanacağı açık bir şekilde gösterilmiştir. Katılımcılar verilen örnek tasarım yerine kendilerinin belirlediği ve kendilerine özgü bir tasarım yapmaları gerekmektedir.

SENARYO	Etkinlik ile ilgili problem durumunu anlatan senaryo

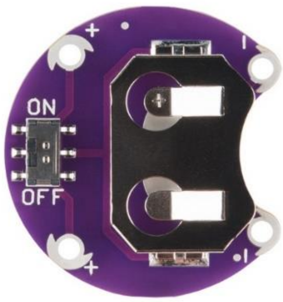
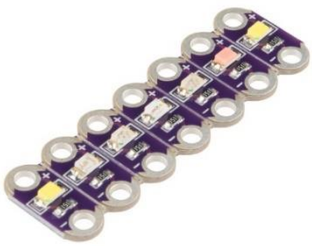
Özel bir okul olan Ulus Ortaokulu 2018 yılında farklı okul içi ve okul dışı etkinlikler düzenleyerek öğrencilere bilimi sevdirmeyi amaçlamaktadır. Neredeyse her dönem yapılan fen, astronomi ve uzay, robotik, matematik ve kodlama etkinliklerine bu dönem teknoloji ve tasarım etkinliği de eklenmiştir. Teknoloji ve tasarım etkinliği için okul tarafından dışarıdan ismi Deniz olan bir üniversite hocası getirilmiştir. Teknoloji ve tasarım alanında uzman olan Deniz Hoca etkinlik ile ilgili bilgi vermek için velileri okula davet eder. Yaklaşık bir saat süren konuşma sonunda veliler etkinliğin sadece tasarım ile sınırlı olmadığını, diğer alanları da kapsadığını öğrenir. Bu durum velileri o kadar etkiler ki kayıt zamanı herkes çocuğunu bu etkinliğe göndermeye çalışır. Etkinliğe bu kadar yoğun bir talep olunca Deniz Hoca öğretmen etkinliğe başvuru yapan öğrenciler arasında bir yarışma düzenler. Yarışmaya öğrenciler ile birlikte velilerin de katılması zorunlu tutulur.

Her öğrencinin velisi ile birlikte giyilebilir teknolojiler ile sanat ve tasarım araçlarını kullanarak özgün bir kolye tasarlaması gerekmektedir. Fakat kolye tasarımı için bazı kurallar getirilmiştir. Örneğin, her grup kolye tasarımı için iki tane LED ve iki tane de pil yuvası dışında herhangi bir giyilebilir teknoloji kullanamamaktadır. Fakat gruplar istedikleri kadar pil kullanma hakkına sahiptirler. Bunun yanında LED’ler üzerinden geçecek toplam voltaj miktarının 3.7 volt üzerinde olması istenmektedir. Ayrıca LED’lerden birinin yanmaması durumunda diğer LED’in de yanmaması gerektiği belirtilmiştir. Bunlara ek olarak kolyenin her iki ucuna dikilen mıknatısların bir anahtar görevi görmesi yani mıknatıslar birleştiğinde LED'lerin yanması ve ayrıldığında ise LED'lerin sönmesi istenmektedir. Yarışma için okulun geniş spor salonu düzenlenir ve her öğrenci ve velisi için bir masa konulur. Yarışmada kullanılacak bütün malzemeler masalara tek tek yerleştirilir. Yarışmanın katılımcılarından birisi de Sevim'dir. Sevim henüz yarım dönemdir ortaokula gitmesine rağmen yarışmada ilk 5 kişinin içinde yer almak istemektedir.

GÖREV	Problem durumuna yönelik yapılması gereken görevler

Kolye tasarımında belirtilen kurallara uyarak Sevim'i ilk 5 kişi içerisine sokacak özelliklere sahip estetik, özgün ve yaratıcı bir kolye tasarlamak. Bu görev kapsamında kullanılacak giyilebilir teknolojiler, sanat ve tasarım araçları, taslak çizim formu, elektronik devre elemanlarının iletken iplik ile birbirine nasıl dikileceğini gösteren devre şeması ve örnek bir tasarım aşağıda belirtilmiştir.

MALZEMELER	Tasarımda kullanılacak malzemeler ile ilgili bilgiler aşağıda verilmiştir

Giyilebilir Teknolojiler	**Sanat ve Tasarım Araçları**
	
Lilypad Para Pil Yuvası (2 Adet)	Keçe
	
Lilypad LED (2 Adet)	İğne

	
Para Pil (2 Adet)	Normal İplik
	
İletken İplik	Demir Çıt Çıt (2 Adet)
	
Dijital Multimetre	Karışık Düğmeler
	
Krokodil Kablo	Karışık Boncuklar

ÖRNEK TASARIMLAR	Aşağıdaki tasarım örnekleri dikilebilir teknolojiler ile birlikte sanat ve tasarım araçları kullanılarak tasarlanmıştır.

	
Böcek Tasarımı	Kuru Kafa Tasarımı
	
Canavar Tasarımı	Cadılar Bayramı Tasarımı
	
Köpek Tasması Tasarımı	Kızgın Kuş Tasarımı

TASLAK ÇİZİMİ	Tasarlanacak projenin taslak çizimi aşağıda detaylı olarak çizilir

DEVRE ŞEMASI	Devre elemanlarının birbirine nasıl dikilmesi gerektiğini gösteren devre şeması

FEN-TEKNOLOJİ-MÜHENDİSLİK-SANAT-MATEMATİK ETKİNLİĞİ - 4

Lilypad Devre Kartı, LED ve Yandan Işıyan Fiber Kablo Kullanarak Ürün Dikme ve Giysi Tasarımı

Program Adı:	Giyilebilir Teknolojiler
KONU:	Temel Elektrik Devreleri ve Kavramları
Hedef Kitle (Yaş Grubu):	Ortaokul Öğrencileri (10 – 14 Yaş Aralığı)
Süre:	2 – 2.5 SAAT

KAZANIMLAR	Etkinlik yoluyla ulaşılması amaçlanan kazanımlar aşağıda belirtilmiştir

Bu etkinliğin amacı giyilebilir teknolojiler ile birlikte sanat ve tasarım araçlarını kullanarak;

- Ortaokul öğrencilerine temel elektrik kavramlarını öğretmek.
- Özgün ve yaratıcı bir ürün tasarlamak.
- Öğrencilerin elektrik devreleri konusu ile ilgili sahip olduğu bilgi ve beceriler günlük hayatta bir amaca ya da bir problemi çözmeye yönelik kullanması.
- Ortaokul öğrencilerini tasarım odaklı düşünme süreçlerinin içerisine aktif olarak katarak sanat ve tasarım yönünden estetik, özgün ve yaratıcı bir ürün tasarlamalarına olanak tanımak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini kullanarak bir ürün geliştirmelerini sağlamak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini artırıp geliştirmelerine olanak tanımak.

ETKİNLİK SÜRECİ	Tasarım boyunca izlenilmesi gereken süreçler aşağıda belirtilmiştir

- Etkinlik sürecinde tasarlanacak olan ürün verilen "Tasarım Odaklı Düşünme Basamakları" takip edilerek gerçekleştirilir. Her basamakta neler yapılması gerektiği açık bir şekilde belirtilmiştir. Katılımcılar ilgili basamakta yapılması gerekenleri yaptıktan sonra bir sonraki basamağa geçmelidir.
- Etkinlikte kullanılacak malzemeler (giyilebilir teknolojiler ile sanat ve tasarım araçları) aşağıda tablo şeklinde verilmiştir. Ürün tasarımında tabloda verilmeyen farklı sanat ve tasarım araçları da kullanılabilir.
- Tasarımda kullanılacak devre şeması örnek bir tasarım üzerinde aşağıda verilmiştir. Devre şeması üzerinde elektronik devrelerin iletken iplik kullanılarak birbirine nasıl dikilerek bağlanacağı açık bir şekilde gösterilmiştir. Katılımcılar verilen örnek tasarım yerine kendilerinin belirlediği ve kendilerine özgü bir tasarım yapmaları gerekmektedir.

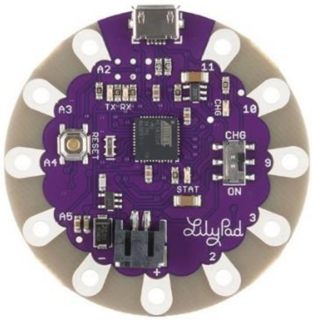
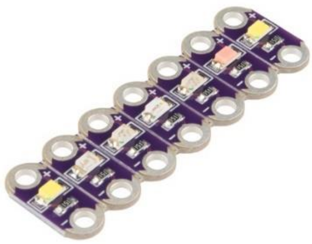
SENARYO	Etkinlik ile ilgili problem durumunu anlatan senaryo

"Yıldız kümesi" Turan'ın okuduğu ilk kitabın adıdır. Babasının internet üzerinden sipariş ettiği kitap ile birlikte onu da hediye olarak göndermişlerdir. Öğretmen olan babası hediye olarak gelen kitabı okulun kütüphanesine götürmek için onu masanın üzerine görünecek bir yere bırakır. Turan odada dolaşırken gözü kitabın kapağındaki resme takılır ve kitabı alıp göz gezdirmek ister. Kitabın üzerinde büyük harflerle "Yıldız Kümesi" yazar. Turan bunun ne anlama geldiğini öğrenmek için kitabın ilk sayfasını okumaya başlar. Kitap o kadar çok ilgisini çeker ki hiç farkında olmadan 50 sayfalı olan kitabın tamamını hiç ara vermeden okur. Evreni kendi yaşadığı dünyadan ibaret zanneden Turan, kitaptaki resimleri gördükten sonra uzayın büyüklüğüne hayran kalır. O günden sonra ne zaman uzay ve galaksiler ile ilgili bir yazı, resim ve kitap görse onu almaya ve okumaya çalışır. Henüz ortaokula gitmesine rağmen uzayın sonsuzluğuna karşı başlamış olan bu büyük merakı onu teleskop almaya kadar götürür. Her gece gökyüzünün bir kısmını görebildiği, odasında bulunan camın kenarına geçerek teleskobuyla o karanlığın içinde yıldız kümelerini inceler. Bir gün yine gökyüzüne teleskobu ile bakarken daha önce hiç görmediği bir yıldız kümesi görür. Çok heyecanlanan Turan yıldız kümesi ile ilgili bütün detayları en ince ayrıntısına kadar yazmaya başlar. Kaç tane oldukları, ne kadar büyüklükte oldukları, aralarındaki mesafenin ne kadar olduğu ve nasıl bir şekilde göründüklerini göz kararı ile ölçer ve ölçtüğü değerleri defterine kaydeder. Turan'ın aldığı kayıtlarda üç tane yıldızın açık bir şekilde göründüğü ve bu yıldızlardan birinin sürekli yanarken diğer ikisinin ise eşit olmayan aralıklarla yanıp söndüğü yazılıdır. Ayrıca yıldızların olduğu yerde şerit şeklinde bir ışığın farklı renklerde sürekli yanıp söndüğü de not edilmiştir. Turan keşfettiği yıldız kümesinin şeklini daha önce Fen bilgisi dersi için aldığı malzemeleri kullanarak ve yazdığı notları göz önüne alarak tasarlayacaktır.

GÖREV	Problem durumuna yönelik yapılması gereken görevler

Turan'ın not defterinde belirttiği özellikleri yansıtan estetik, özgün ve yaratıcı bir yıldız kümesi tasarlamak. Bu görev kapsamında kullanılacak giyilebilir teknolojiler, sanat ve tasarım araçları, taslak çizim formu, elektronik devre elemanlarının iletken iplik ile birbirine nasıl dikileceğini gösteren devre şeması ve örnek bir tasarım aşağıda belirtilmiştir.

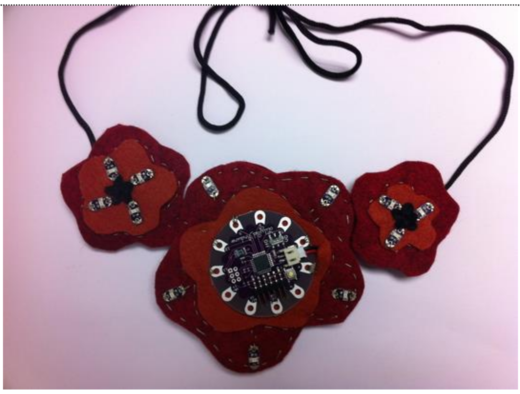
MALZEMELER	Tasarımda kullanılacak malzemeler ile ilgili bilgiler aşağıda verilmiştir

Giyilebilir Teknolojiler	Sanat ve Tasarım Araçları
	
Lilypad USB Kartı	Keçe
	
Lilypad LED (3 adet)	İğne

	
RGB Power LED	Normal İplik
	
Batarya	Boncuk
	
İletken İplik	Cetvel
	
Yandan Işıyan Fiber Kablo	Makas

	
Daralan Makaron	Tekstil Yapıştırıcı

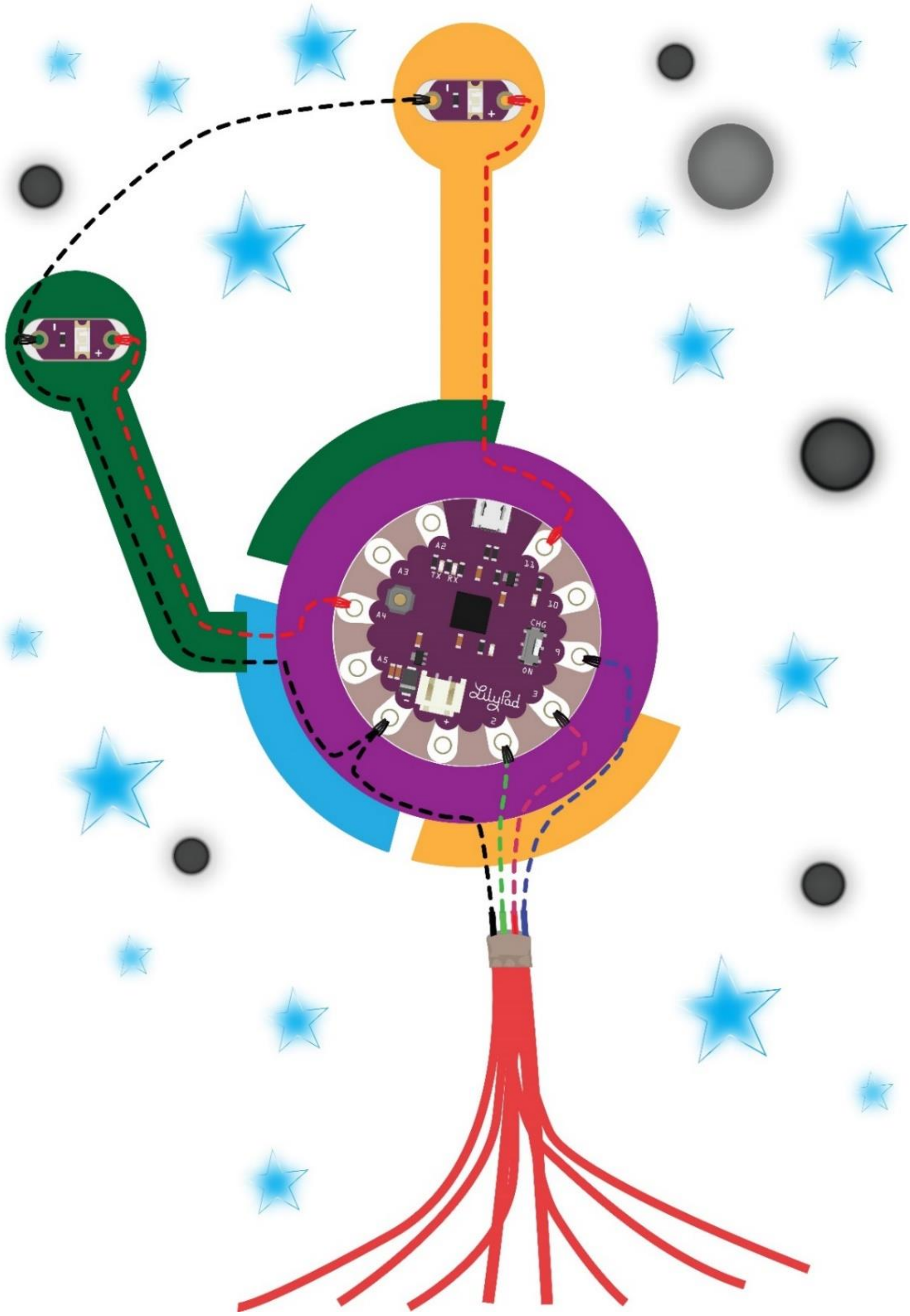
ÖRNEK TASARIMLAR	Aşağıdaki tasarım örnekleri dikilebilir teknolojiler ile birlikte sanat ve tasarım araçları kullanılarak tasarlanmıştır.

	
Giysi Tasarımı	Saç Bandı Tasarımı
	
Kolye Tasarımı	Roket Tasarımı

	
Giysi Tasarımı	Şapka Tasarımı

TASLAK ÇİZİMİ	Tasarlanacak projenin taslak çizimi aşağıda detaylı olarak çizilir

DEVRE ŞEMASI	Devre elemanlarının birbirine nasıl dikilmesi gerektiğini gösteren devre şeması



FEN-TEKNOLOJİ-MÜHENDİSLİK-SANAT-MATEMATİK ETKİNLİĞİ- 5

Işık Sensörü ve Neopixel Kullanarak Belirli Bir Işık Seviyesinden Sonra Farklı Renklerde Isık Veren Deniz Feneri Dikme ve Giysi Tasarımı

Program Adı:	Giyilebilir Teknolojiler
KONU:	Temel Elektrik Devreleri ve Kavramları
Hedef Kitle (Yaş Grubu):	Ortaokul Öğrencileri (10 – 14 Yaş Aralığı)
Süre:	2 – 2.5 SAAT

KAZANIMLAR	Etkinlik yoluyla ulaşılması amaçlanan kazanımlar aşağıda belirtilmiştir

Bu etkinliğin amacı giyilebilir teknolojiler ile birlikte sanat ve tasarım araçlarını kullanarak;

- Ortaokul öğrencilerine temel elektrik kavramlarını öğretmek.
- Özgün ve yaratıcı bir ürün tasarlamak.
- Öğrencilerin elektrik devreleri konusu ile ilgili sahip olduğu bilgi ve beceriler günlük hayatta bir amaca ya da bir problemi çözmeye yönelik kullanması.
- Ortaokul öğrencilerini tasarım odaklı düşünme süreçlerinin içerisine aktif olarak katarak sanat ve tasarım yönünden estetik, özgün ve yaratıcı bir ürün tasarlamalarına olanak tanımak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini kullanarak bir ürün geliştirmelerini sağlamak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini artırıp geliştirmelerine olanak tanımak.

ETKİNLİK SÜRECİ	Tasarım boyunca izlenilmesi gereken süreçler aşağıda belirtilmiştir

- Etkinlik sürecinde tasarlanacak olan ürün verilen “Tasarım Odaklı Düşünme Basamakları” takip edilerek gerçekleştirilir. Her basamakta neler yapılması gerektiği açık bir şekilde belirtilmiştir. Katılımcılar ilgili basamakta yapılması gerekenleri yaptıktan sonra bir sonraki basamağa geçmelidir.
- Etkinlikte kullanılacak malzemeler (giyilebilir teknolojiler ile sanat ve tasarım araçları) aşağıda tablo şeklinde verilmiştir. Ürün tasarımında tabloda verilmeyen farklı sanat ve tasarım araçları da kullanılabilir.
- Tasarımda kullanılacak devre şeması örnek bir tasarım üzerinde aşağıda verilmiştir. Devre şeması üzerinde elektronik devrelerin iletken iplik kullanılarak birbirine nasıl dikilerek bağlanacağı açık bir şekilde gösterilmiştir. Katılımcılar verilen örnek tasarım yerine kendilerinin belirlediği ve kendilerine özgü bir tasarım yapmaları gerekmektedir.

SENARYO	Etkinlik ile ilgili problem durumunu anlatan senaryo

Fen ve teknoloji dersinde öğrencilerin dönem sonunda bireysel bir proje tasarlamaları ve daha sonra bu projeyi sınıfta sunmaları istenmektedir. Proje kapsamında her öğrenciye belirli sayıda ve farklı giyilebilir teknoloji malzemeleri verilmektedir. Öğrencilerin bu malzemeleri kullanarak gerçek hayat ile ilişkili bir ürün tasarlamaları istenmektedir. Örneğin eğer bir öğrenciye proje tasarımı için Lilypad kartı ve sarı, yeşil ve kırmızı renkte 3 tane LED verilmişse o öğrencinin trafik lambası tasarlaması projede yüksek bir puan almasını sağlayacaktır. Bu yüzden projelerde tasarlanacak ürün ile o ürün için kullanılan giyilebilir teknolojiler arasında bir ilişki olması beklenmektedir. Fen ve teknoloji dersini bu dönem alan Deniz’e projesinde kullanması için kendisine aşağıdaki giyilebilir teknolojiler verilmiştir:

- Lilypad USB Kartı

- Neopixel

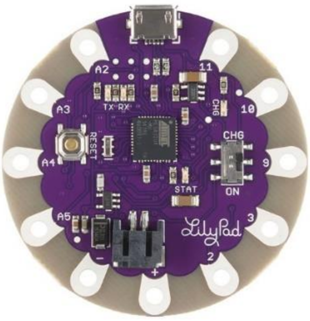
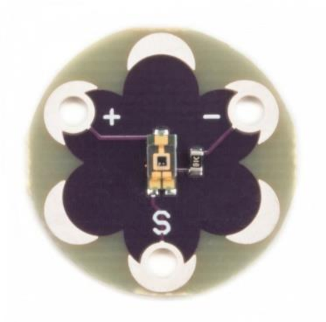
- Işık Sensörü

Denizin bu teknolojiler ile birlikte sanat ve tasarım araçlarını kullanarak gerçek hayat ile ilişkili yaratıcı bir ürün tasarlaması bekleniyor.

GÖREV	Problem durumuna yönelik yapılması gereken görevler

Deniz’in projede yüksek bir puan almasını sağlayacak gerçek hayat ile ilişki ve tasarım açısından estetik, özgün ve yaratıcı bir deniz feneri tasarlamak. Bu görev kapsamında kullanılacak giyilebilir teknolojiler, sanat ve tasarım araçları, taslak çizim formu, elektronik devre elemanlarının iletken iplik ile birbirine nasıl dikileceğini gösteren devre şeması ve örnek bir tasarım aşağıda belirtilmiştir.

MALZEMELER	Tasarımda kullanılacak malzemeler ile ilgili bilgiler aşağıda verilmiştir

Giyilebilir Teknolojiler	Sanat ve Tasarım Araçları
	
Lilypad USB Kartı	Keçe
	
Neopixel (1 Adet)	İğne
	

Işık Sensörü	Normal İplik
	
Batarya	Karışık Düğmeler
	
İletken İplik	Karışık Boncuklar

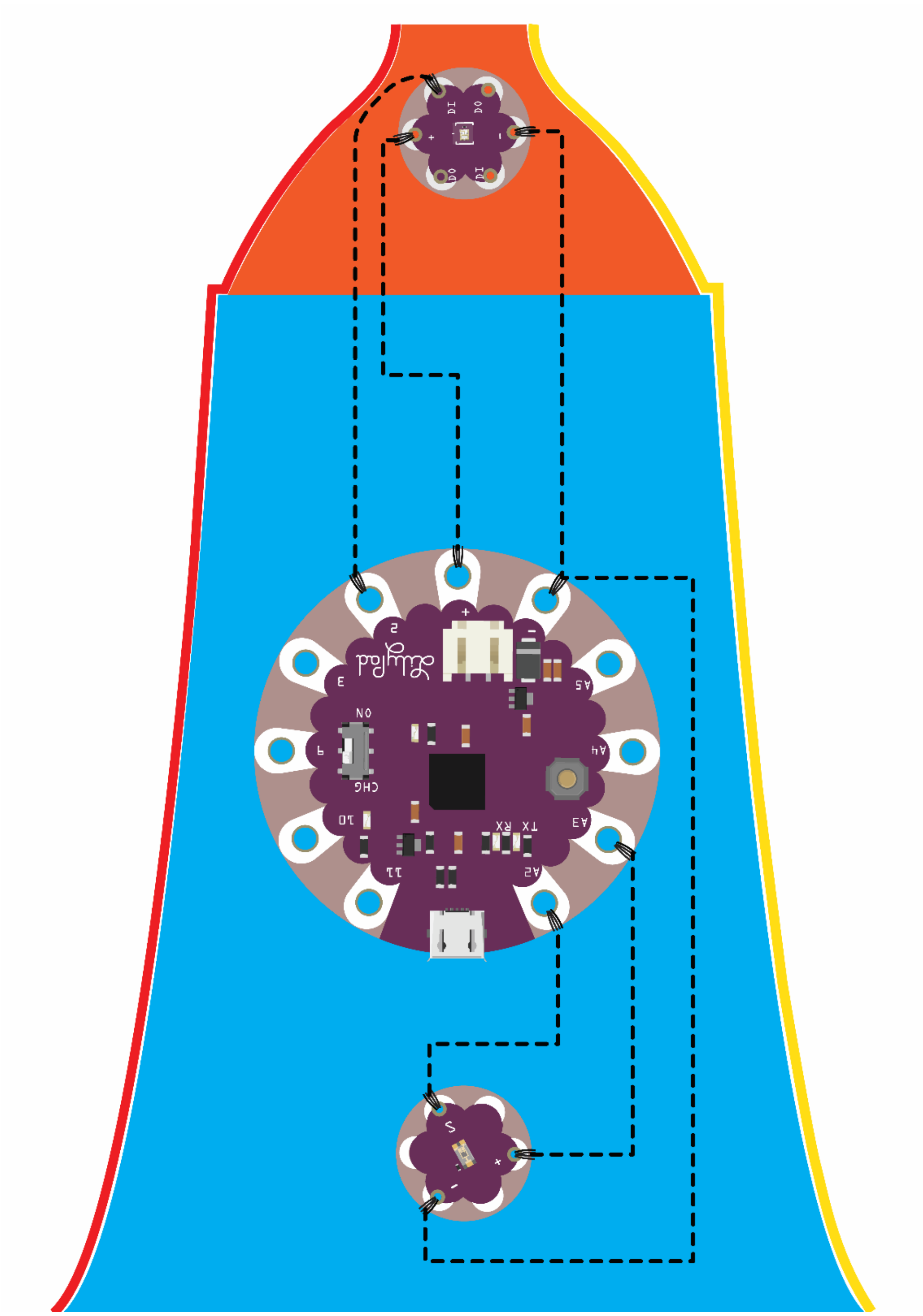
ÖRNEK TASARIMLAR	Aşağıdaki tasarım örnekleri dikilebilir teknolojiler ile birlikte sanat ve tasarım araçları kullanılarak tasarlanmıştır.

	
Giysi Tasarımı	Cadılar Bayramı Tasarımı

	
Çanta Tasarımı	Fos Fos Araba Tasarımı
	
Hayvan Resmi Tasarımı	Sevgililer Günü Kalp Tasarımı

TASLAK ÇİZİMİ	Tasarlanacak projenin taslak çizimi aşağıda detaylı olarak çizilir

DEVRE ŞEMASI	Devre elemanlarının birbirine nasıl dikilmesi gerektiğini gösteren devre şeması



FEN-TEKNOLOJİ-MÜHENDİSLİK-SANAT-MATEMATİK
ETKİNLİĞİ- 6

Lilypad Devre Kartı, Sıcaklık Sensörü ve LED Kullanarak Ortam Sıcaklığını Ölçen ve Sıcaklık Değerine Göre LED'leri Yakıp Söndüren Ürün Dikme ve Giysi Tasarımı

Program Adı:	Giyilebilir Teknolojiler
KONU:	Temel Elektrik Devreleri ve Kavramları
Hedef Kitle (Yaş Grubu):	Ortaokul Öğrencileri (10 – 14 Yaş Aralığı)
Süre:	2 – 2.5 SAAT
KAZANIMLAR	Etkinlik yoluyla ulaşılması amaçlanan kazanımlar aşağıda belirtilmiştir

Bu etkinliğin amacı giyilebilir teknolojiler ile birlikte sanat ve tasarım araçlarını kullanarak;

- Ortaokul öğrencilerine temel elektrik kavramlarını öğretmek.
- Özgün ve yaratıcı bir ürün tasarlamak.
- Öğrencilerin elektrik devreleri konusu ile ilgili sahip olduğu bilgi ve beceriler günlük hayatta bir amaca ya da bir problemi çözmeye yönelik kullanması.
- Ortaokul öğrencilerini tasarım odaklı düşünme süreçlerinin içerisine aktif olarak katarak sanat ve tasarım yönünden estetik, özgün ve yaratıcı bir ürün tasarlamalarına olanak tanımak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini kullanarak bir ürün geliştirmelerini sağlamak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini artırıp geliştirmelerine olanak tanımak.

ETKİNLİK SÜRECİ	Tasarım boyunca izlenilmesi gereken süreçler aşağıda belirtilmiştir

- Etkinlik sürecinde tasarlanacak olan ürün verilen "Tasarım Odaklı Düşünme Basamakları" takip edilerek gerçekleştirilir. Her basamakta neler yapılması gerektiği açık bir şekilde belirtilmiştir. Katılımcılar ilgili basamakta yapılması gerekenleri yaptıktan sonra bir sonraki basamağa geçmelidir.
- Etkinlikte kullanılacak malzemeler (giyilebilir teknolojiler ile sanat ve tasarım araçları) aşağıda tablo şeklinde verilmiştir. Ürün tasarımında tabloda verilmeyen farklı sanat ve tasarım araçları da kullanılabilir.
- Tasarımda kullanılacak devre şeması örnek bir tasarım üzerinde aşağıda verilmiştir. Devre şeması üzerinde elektronik devrelerin iletken iplik kullanılarak birbirine nasıl dikilerek bağlanacağı açık bir şekilde gösterilmiştir. Katılımcılar verilen örnek tasarım yerine kendilerinin belirlediği ve kendilerine özgü bir tasarım yapmaları gerekmektedir.

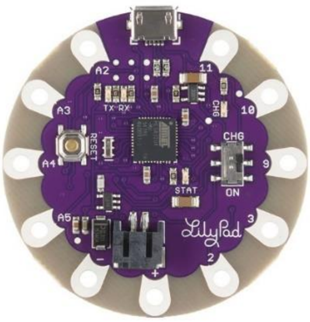
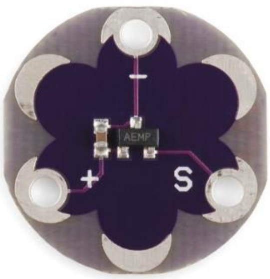
SENARYO	Etkinlik ile ilgili problem durumunu anlatan senaryo

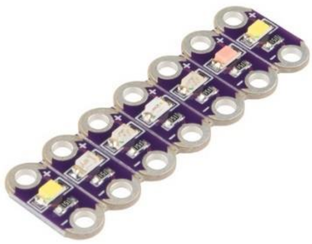
Barbaros Ortaokulunda Fen Bilgisi öğretmeni olan Melek Öğretmen okulda neredeyse ikinci yılını doldurmaktadır. Bir sene önce öğrencilerin fen ve teknolojiye yönelik görmüş olduğu kavramları günlük hayatla ilişkilendirmesini sağlamak için başlatmış olduğu projeyi her dönem uygulamaktadır. Bu dönem de içinde proje zamanı gelip çatmıştır. Her dönem olduğu gibi öğrenciler proje konusunun ne olacağını sabırsızlıkla bekliyorlardır. Ders zili çalar ve bütün öğrenciler sınıfa koşar. Melek Öğretmen hemen arkalarından sınıfa girer ve proje konusunu duyurmak için hazırlanır. Sınıfın sessizliği Melek Öğretmen'in proje konusunun "Elektrik Devreleri" olarak belirtmesi ile bir anda karmaşaya dönüşür. Proje konusu açıklandığı için artık herkes projede beraber çalışacak kişi bulmaya başlar. İkişer kişilik grup halinde yapılacak olan projede her grubun bir proje önerisi ile gelmesi gerekir. İki kişi haricinde sınıftaki her öğrenci beraber proje yapacak birisini bulmuş ve proje önerisini vermiştir. Birisi sınıfın arka sağ köşesinde oturan Veli, diğeri ise sınıfın ön sol köşesinde oturan Zelal'dır. Melek Öğretmen ikisinden başka kimse kalmadığı için Veli ve Zelal'ı proje grup arkadaşı yapar. Proje konuları havada uçuşmuştur. Kimi grup trafik ışıklarını yapacağız derken kimi grup ise biz sokak lambası tasarlayacağı der. Akla gelebilecek konuların çoğu seçildiği için Veli ve Zelal konu bulmak için düşünmeye ve seçenekleri değerlendirmeye başlar. Projelerin yapılacağı dönem yaz aylarına denk geldiği için havalar oldukça sıcak ve nemlidir. Havalar o kadar çok sıcak olur ki bazen öğle zamanları yol üstündeki asfalt hafifçe erimeye başlar. O gün yine böyle sıcak bir günde Veli ve Zelal ders çıkışı asfalttan yapılmış olan okul bahçesinde gezinirken ayakları eriyen asfalta yapışır ve o anda akıllarına sıcaklığı ölçen bir termometre tasarlama fikri gelir. Termometre tasarımında 4 adet LED kullanmaya karar verirler. LED'lerin ortam sıcaklığına bağlı olarak yanmasında şöyle bir planlamaya giderler: Normal oda sıcaklığında bir tane LED yanacak ve sıcaklık yükseldikçe yanan LED sayısı artacak. Ortam sıcaklığı yükselip 3 tane LED yandığında termometre sıcaklık değerinin yüksek olduğunu gösteren uyarı sesi verecektir.

GÖREV	Problem durumuna yönelik yapılması gereken görevler

Belirtilen özelliklere sahip ve tasarım açısından estetik, özgün ve yaratıcı bir termometre tasarlamak. Bu görev kapsamında kullanılacak giyilebilir teknolojiler, sanat ve tasarım araçları, elektronik devre elemanlarının iletken iplik ile birbirine nasıl dikileceğini gösteren devre şeması ve örnek bir tasarım aşağıda belirtilmiştir.

MALZEMELER	Tasarımda kullanılacak malzemeler ile ilgili bilgiler aşağıda verilmiştir

Giyilebilir Teknolojiler (Adet)	Sanat ve Tasarım Araçları
	
Lilypad USB Kartı (1)	Keçe
	
Sıcaklık Sensörü (1)	İğne

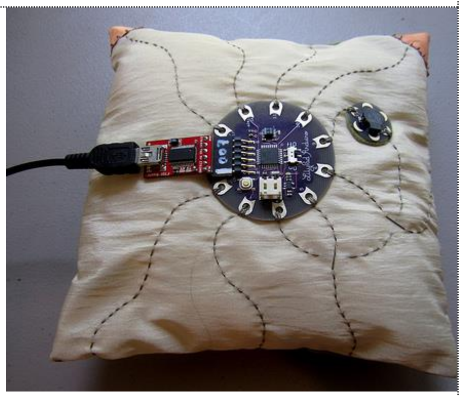
	
Buzzer (1)	Normal İplik
	
Batarya (1)	Karışık Düğmeler
	
Lilypad LED (4)	Karışık Boncuklar
	
İletken İplik	Cetvel

ÖRNEK TASARIMLAR	Aşağıdaki tasarım örnekleri dikilebilir teknolojiler ile birlikte sanat ve tasarım araçları kullanılarak tasarlanmıştır.

Nefes Sıcaklığına Duyarlı Atkı Tasarımı

Vücut Sıcaklığına Duyarlı Boyun Yakası Tasarımı

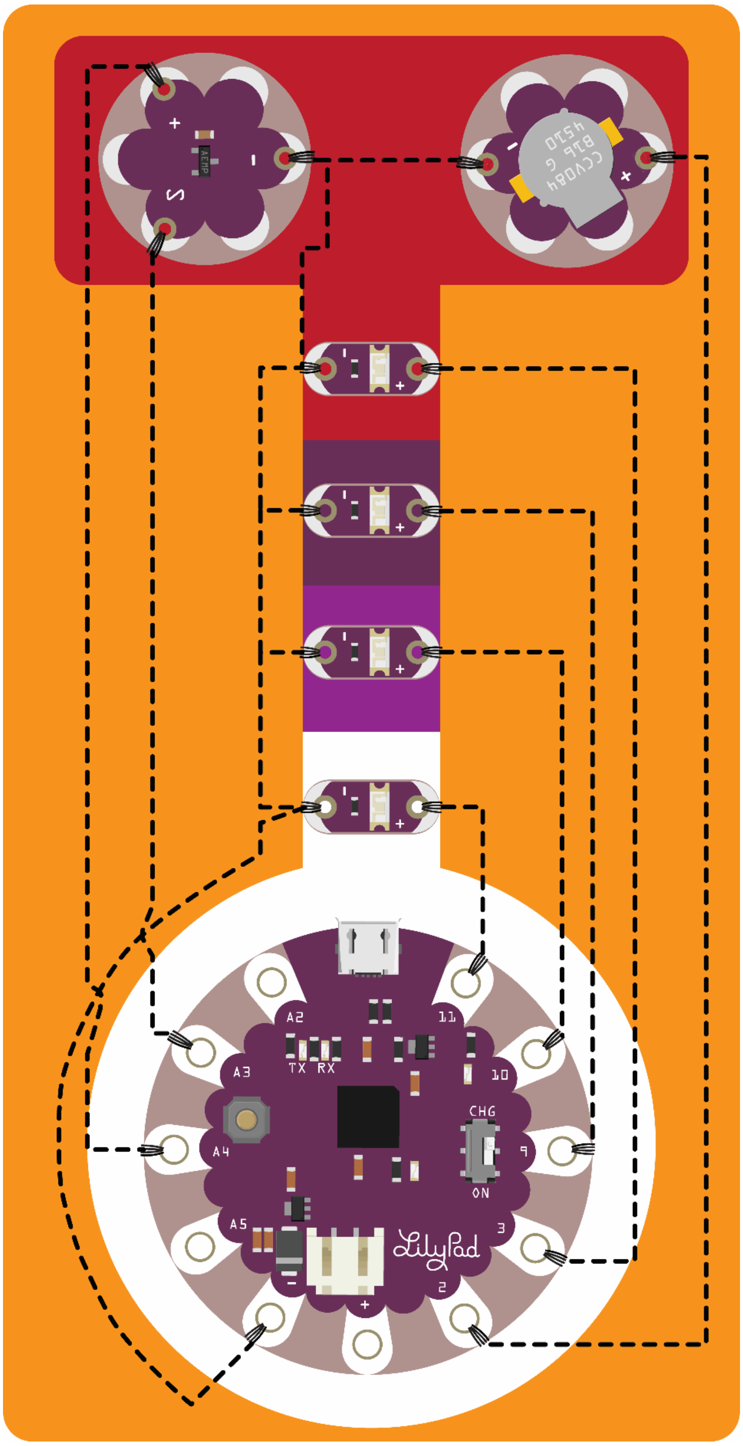
Ortamdaki Sıcaklığa Duyarlı Eldiven Tasarımı



Farklı Müzik Notası Çıkaran Yastık Tasarımı

TASLAK ÇİZİMİ	Tasarlanacak projenin taslak çizimi aşağıda detaylı olarak çizilir

DEVRE ŞEMASI	Devre elemanlarının birbirine nasıl dikilmesi gerektiğini gösteren devre şeması



FEN-TEKNOLOJİ-MÜHENDİSLİK-SANAT-MATEMATİK ETKİNLİĞİ- 7

Lilypad Devre Kartı, Renk Sensörü ve Neopixel Kullanarak Ortamdaki Renge Göre Renk Değiştiren Ürün Dikme ve Giysi Tasarımı

Program Adı:	Giyilebilir Teknolojiler
KONU:	Temel Elektrik Devreleri ve Kavramları
Hedef Kitle (Yaş Grubu):	Ortaokul Öğrencileri (10 – 14 Yaş Aralığı)
Süre:	2 – 2.5 SAAT

KAZANIMLAR	Etkinlik yoluyla ulaşılması amaçlanan kazanımlar aşağıda belirtilmiştir

Bu etkinliğin amacı giyilebilir teknolojiler ile birlikte sanat ve tasarım araçlarını kullanarak;

- Ortaokul öğrencilerine temel elektrik kavramlarını öğretmek.
- Özgün ve yaratıcı bir ürün tasarlamak.
- Öğrencilerin elektrik devreleri konusu ile ilgili sahip olduğu bilgi ve beceriler günlük hayatta bir amaca ya da bir problemi çözmeye yönelik kullanması.
- Ortaokul öğrencilerini tasarım odaklı düşünme süreçlerinin içerisine aktif olarak katarak sanat ve tasarım yönünden estetik, özgün ve yaratıcı bir ürün tasarlamalarına olanak tanımak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini kullanarak bir ürün geliştirmelerini sağlamak.
- Ortaokul öğrencilerinin STEAM -Fen, Teknoloji, Mühendislik, Sanat, Matematik- alanlarındaki bilgi ve becerilerini artırıp geliştirmelerine olanak tanımak.

ETKİNLİK SÜRECİ	Tasarım boyunca izlenilmesi gereken süreçler aşağıda belirtilmiştir

- Etkinlik sürecinde tasarlanacak olan ürün verilen "Tasarım Odaklı Düşünme Basamakları" takip edilerek gerçekleştirilir. Her basamakta neler yapılması gerektiği açık bir şekilde belirtilmiştir. Katılımcılar ilgili basamakta yapılması gerekenleri yaptıktan sonra bir sonraki basamağa geçmelidir.
- Etkinlikte kullanılacak malzemeler (giyilebilir teknolojiler ile sanat ve tasarım araçları) aşağıda tablo şeklinde verilmiştir. Ürün tasarımında tabloda verilmeyen farklı sanat ve tasarım araçları da kullanılabilir.
- Tasarımda kullanılacak devre şeması örnek bir tasarım üzerinde aşağıda verilmiştir. Devre şeması üzerinde elektronik devrelerin iletken iplik kullanılarak birbirine nasıl dikilerek bağlanacağı açık bir şekilde gösterilmiştir. Katılımcılar verilen örnek tasarım yerine kendilerinin belirlediği ve kendilerine özgü bir tasarım yapmaları gerekmektedir.

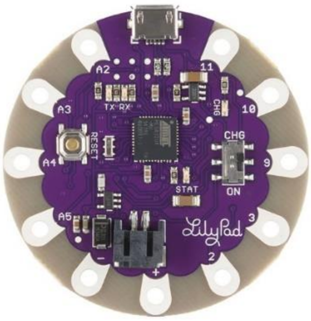
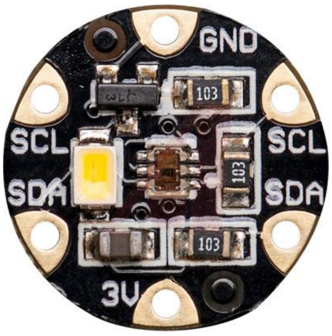
SENARYO	Etkinlik ile ilgili problem durumunu anlatan senaryo

Yatılı bir bölge okulu olan Cumhuriyet Ortaokulunda her dönem belirli bir temaya göre moda ve tasarım sergisi düzenlemekte ve bu sergide dönem boyunca öğrenciler tarafından yapılan tasarımlar sergilenmektedir. Sergiye okul öğretmenleri ile birlikte veliler de katılmakta ve en iyi tasarımı seçmek için oy kullanmaktadır. Bu dönemki sergide yapılacak tasarımların "moda" temasına uygun olması gerektiği belirlenmiştir. Bunun için sergiye ürün gönderecek grupların giyilebilir teknolojiler kullanarak bir atkı tasarlamaları beklenmektedir. Tasarlanacak atkının üzerindeki renk sensörü sayesinde ortamın rengine göre renk değiştirmesi ve bu renklerin telefon üzerinden kontrol edilebiliyor olması özelliklerini taşıması istenmektedir. Ayrıca gruplara tasarımlarını zenginleştirmek için istedikleri kadar sanat ve tasarım araçlarını kullanabilecekleri belirtilmiştir. Her derste olduğu gibi Teknoloji ve Tasarım dersinde de iki kişiden oluşan bir grup oluşturulmuştur Her gruba o dersin öğretmeni de destek vermektedir. Teknoloji ve Tasarım dersinin öğretmeni olan Kemal, projeye katılacak iki öğrenciyi çağırarak yapacakları tasarım hakkında konuşmuştur. Yapılan beyin fırtınası ve fikir alışverişinden sonra yapılacak tasarımın özgün ve estetik olması gerektiği sonucuna ulaşılmıştır. Tasarım süreci için de tasarım odaklı düşünme basamaklarını izlemeleri gerektiğine karar verilmiştir.

GÖREV	Problem durumuna yönelik yapılması gereken görevler

Belirtilen özelliklere sahip ve tasarım açısından estetik, özgün ve yaratıcı bir atkı tasarlamak. Bu görev kapsamında kullanılacak giyilebilir teknolojiler, sanat ve tasarım araçları, taslak çizim formu, elektronik devre elemanlarının iletken iplik ile birbirine nasıl dikileceğini gösteren devre şeması ve örnek bir tasarım aşağıda belirtilmiştir.

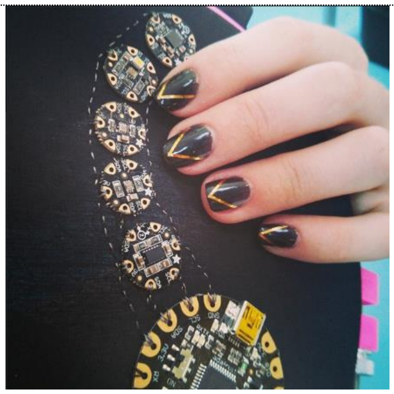
MALZEMELER	Tasarımda kullanılacak malzemeler ile ilgili bilgiler aşağıda verilmiştir

Giyilebilir Teknolojiler (Adet)	Sanat ve Tasarım Araçları
	
Lilypad USB Devre Kartı (1)	Kumaş
	
Renk Sensörü (1)	Keçe
	

Batarya (1)	Kurdele
	
Neopixel (3)	İğne
	
İletken İplik	Normal İplik

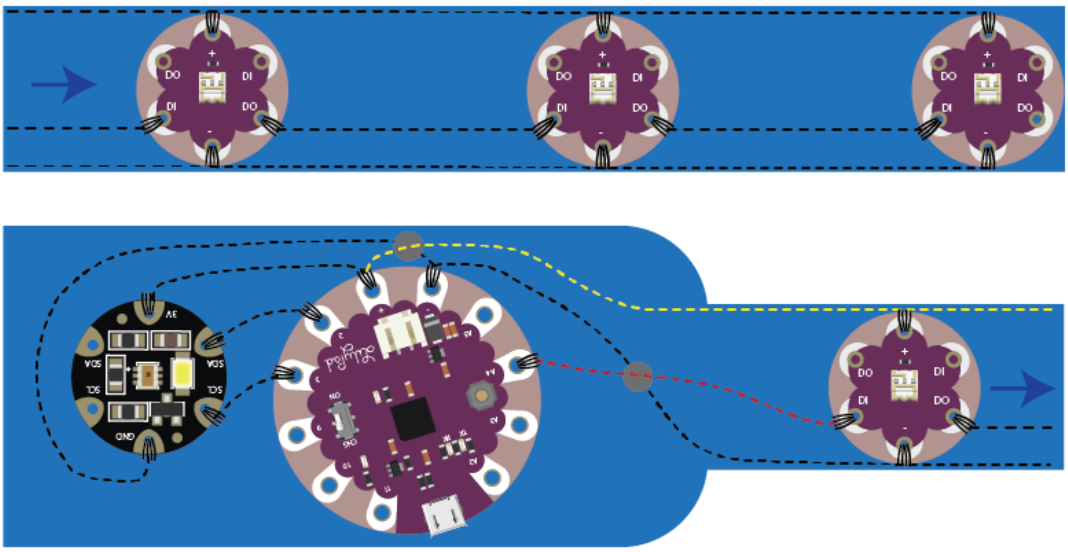
ÖRNEK TASARIMLAR	Aşağıdaki tasarım örnekleri dikilebilir teknolojiler ile birlikte sanat ve tasarım araçları kullanılarak tasarlanmıştır.

	
İstenilen Renge Dönüşen Atkı Tasarımı	İstenilen Renge Dönüşen Şemsiye Tasarımı

	
İstenilen Renge Dönüşen Kumaş Tasarımı	İstenilen Renge Dönüşen Çanta Tasarımı

TASLAK ÇİZİMİ	Tasarlanacak projenin taslak çizimi aşağıda detaylı olarak çizilir

DEVRE ŞEMASI	Devre elemanlarının birbirine nasıl dikilmesi gerektiğini gösteren devre şeması



Dijital Multimetre Kullanımı

Multimetre nedir?

Multimetre, elektronik devre elemanları ile ilgili bilgi edinmek için kullanılan bir ölçme aletidir.

Multimetre Kullanılarak Neler Ölçülebilir?

Standart özelliklere sahip bir Multimetre kullanılarak aşağıda listelenmiş ölçümler ve testler yapılabilir:

- Elektronik devrelerin sağlamlığını test etme
- Devredeki bozuk parçaları belirleme
- Kısa devreyi kontrol etme
- Voltaj (gerilim) ölçümlü
- Akım ölçümü
- Direnç ölçümü
- Frekans ölçümü
- Diyot ölçümü

Multimetre Parçaları

Prob [Probes]: Multimetrede ölçüm prob adı verilen ve multimetreye takılan "siyah" ve "kırmızı" olmak üzere iki kabloyla yapılmaktadır.

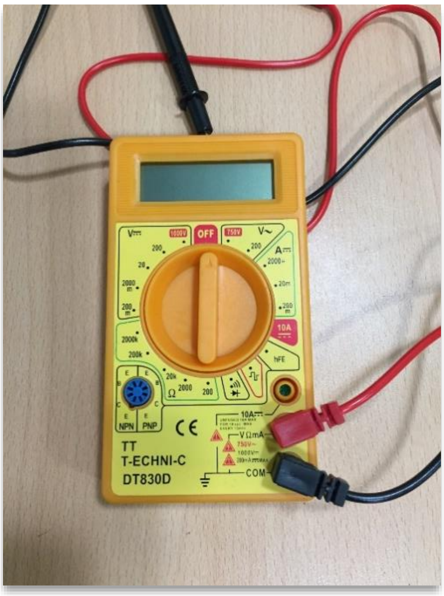
Jak [Jack]: Multimetre cihazı üzerinde sağ alt köşede COM, VΩmA (volt, ohm, miliamper), ve 10A(Amper) üç farklı jak bulunmaktadır.

LCD Ekran: Multimetre cihazı üzerinde bulunan ekran ölçülmüş olan değerleri sayısal olarak gösterir.

Kademe düğmesi: Ölçülecek değerleri seçmek için kullanılan kısım.

Prob bağlantı yerleri

Ortak (Eksi) Jak [Common (Negative) Jack]: Siyah renkli olan prob toprak ucu olarak geçer ve her zaman multimetre cihazı üzerinde yanında "COM" yazan jaka takılır. Tüm ölçüm ve testlerde siyah probe "COM" jakına bağlı olacak şekilde kullanılır.



Pozitif Jak [Positive Jack]: Multimetre cihazı üzerinde yanında Gerilim (V), Direnç (Ω), ve Akım (mA) yazan jaka kırmızı renkli olan probe takılır. Tüm ölçüm ve testlerde kırmızı prob "VΩmA" jakına bağlı olacak şekilde kullanılır.

Multimetre ile voltaj nasıl ölçülür?

Kapalı bir devrede Multimetre kullanılarak devre elemanları üzerinden geçen voltajı ölçmek için aşağıdaki adımlar takip edilir.

Siyah ve kırımız renkli problar jaklara takılı durumda iken;

1. Multimetre kademe anahtarını ölçmek istediğiniz ölçü biriminin türü üzerine getirin. Ölçü birim türü olarak doğru akımı (DA) ve 0 - 20 aralığında bir voltaj (gerilim) ölçeceğimiz için yandaki şekilde görüldüğü gibi kademe anahtarını doğru akım bölümünde 20 üzerine getirin.

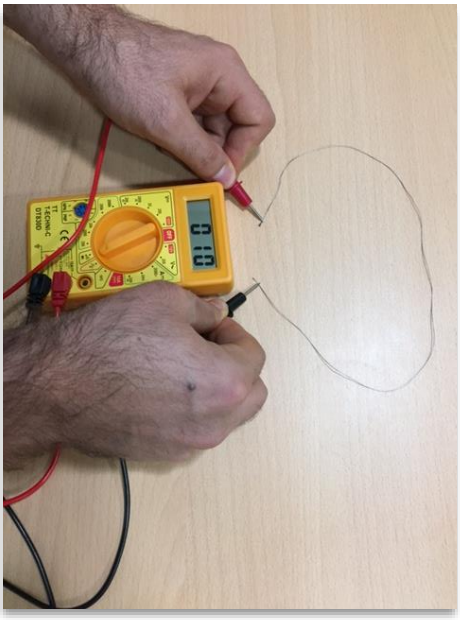
2. Kapalı devre çalışır durumdayken siyah probun iletken ucunu LED in eksi (-) ucuna, kırmızı probun iletken ucunu LED in artı (+) ucuna dokunacak şekilde elinizle tutun.

3. LCD ekranında gördüğünüz sayı LED'den geçen voltajın değerini gösterir.

Bir iletkenin direnci nasıl ölçülür?

1. Siyah renkli probu “COM” jakına ve kırmızı renkli probu “VΩmA” jakına taktıktan sonra kademe anahtarını yandaki şekilde gösterildiği gibi “sesli süreklilik testi” pozisyonuna getirin. Sesli süreklilik testinin çalışıp çalışmadığını anlamak için şekildeki gibi probun uçlarını birbirine dokundurun. Eğer “bip” sesi geliyorsa ve ekrandaki değer sıfıra doğru yaklaşıyorsa testimiz çalışıyor demektir.

2. Direncini ölçmek istediğiniz kablonun bir ucuna herhangi bir probun ucunu, diğer ucuna da diğer probun ucunu dokundurun. Eğer bip sesi alıyorsanız kablonuzda bir kopukluk yok demektir. LCD ekranında çıkan değer ölçmüş olduğunuz kablonun o uzunluktaki direnç büyüklüğünü gösterir.



<u>Önemli Bilgi:</u> Bir iletkenin boyu ile direnci doğru orantılıdır. Yani boyu uzadıkça direnci de artar, boyu kısaldıkça direnci de azalır. Direnci büyük olan kablolarda enerji kaybı yüksek olduğu için elektrik enerjisinin iletimi de düşük olur. Dolaysıyla bir iletkenin direnci ne kadar düşükse enerji kaybı o kadar düşük ve iletkenlik kalitesi de o kadar yüksek olur.

Bir devre parçasının (örneğin LED’in) sağlamlığı nasıl test edilir?

1. Siyah renkli probu “COM” jakına ve kırmızı renkli probu “VΩmA” jakına taktıktan sonra kademe anahtarını yandaki şekilde gösterildiği gibi “sesli süreklilik testi” pozisyonuna getirin.

2. Sağlamlığını test etmek istediğiniz LED’in eksi (+) ucuna siyah renkli probu, artı (+) ucuna da kırmızı renkli probu dokunacak şekilde elinizle tutun. Eğer test ettiğiniz LED şekildeki gibi yanıyorsa LED’in sağlamlılığı ile ilgili bir problem yok demektir.

I. Stages in the Design Thinking Process (Tasarım Odaklı Düşünme Süreci Basamakları)

1 Senaryoya Yönelik Problemi Tanımlama	Birinci basamakta etkinlik ile ilgili verilen senaryo detaylı olarak okunur. Senaryo gerçek yaşamdan ya da hayali olaylardan derlenerek yapılandırılmış birden fazla çözümü olan problemleri yansıtmaktadır. Bu yüzden senaryo okunurken problemin ya da problemlerin neler olduğu doğru bir şekilde tanımlanması gerekir. Çünkü problem ne kadar doğru tanımlanırsa, problemin çözümüne yönelik oluşturulan tasarım da o derece başarılı olur. Senaryoda verilen problemin ne olduğu anlaşıldıktan sonra ikinci basamağa geçilir.
2 Tanımlanan Probleme Yönelik Çözüm Üretme	İkinci basamakta eldeki malzemeler (giyilebilir teknolojiler-sanat ve tasarım araçları) göz önünde bulundurularak tanımlanan probleme yönelik olası tasarım çözümleri üretilir. Bu kapsamda gruptaki üyeler arasında beyin fırtınası ve fikir alışverişi yapılır ve problemi çözebilecek alternatif çözüm yöntemleri üzerinde tartışılır. Çözüm yöntemi çok boyutlu olarak düşünülmelidir. Bu yüzden tasarımsal bir çözüm üretirken o tasarımın hem teknolojik hem de sanat boyutu ayrı ayrı değerlendirilmelidir. Aynı zamanda bu iki boyut arasında bir bütünlük olmasına da dikkat edilmesi gerekir. Çözüm üretme sürecinde çevrimiçi ve çevrimdışı kaynaklar (kitap, resim, vs.) kullanılabilir. Bununla birlikte öne sürülen çözüm yöntemini geliştirmek ve detaylandırmak için yapılmış benzer çözümlerden de destek alınabilir. Probleme yönelik en iyi çözüm yöntemi konusunda ortak bir karar oluştuktan sonra üçüncü basamağa geçilir.
3 Üretilen Çözüme Yönelik Taslak Çizme	Üçüncü basamak, tasarımsal şema ve taslak çiziminden oluşur. Bu kapsamda, bir önceki adımda belirlenen çözüm yönteminin tüm detaylarını içeren bir taslak çizilir. Bu çizim için taslak çizim formu kullanılır. Taslak çizimi tasarımın genel özelliklerini belirler ve genel olarak daha bitmemiş bir işin planlamasının yapıldığı hali tasvir eder. Diğer bir deyişle taslak çizimi düşüncede ve fikirde kalan veya üretilen çözümün karşımızdakinin anlayabileceği şekilde fiziksel olarak kâğıt

	üzerinde basitçe çizilmesidir. Bu yüzden taslak çiziminde tasarım sürecinde kullanılacak olan malzemelerin (giyilebilir teknolojiler- sanat ve tasarım araçları) sayısı, miktarı, oranı, çeşidi, rengi, büyüklüğü, nerde ve nasıl kullanılacağı, konumu vs. detaylı olarak belirtilmelidir. Bununla birlikte giyilebilir teknolojilerin tasarım üzerindeki konumu ve nereye dikileceği verilen devre şemasının yapısı göz önünde bulundurularak taslak üzerinde belirtilmelidir. Taslak çizimi bütün detayları ile birlikte bittikten sonra dördüncü basamağa geçilir.
4 Taslak Çizimi Doğrultusunda Malzemeleri Toplama ve Kontrol Etme	Dördüncü basamak, taslak çizimine bağlı olarak kullanılacak malzemelerin seçimi, toplanması ve kontrol edilmesini kapsar. Bu kapsamda taslak çiziminde özellikleri ile birlikte belirtilmiş olan bütün malzemeler (giyilebilir teknolojiler- sanat ve tasarım araçları) bir araya getirilir. Tasarım sürecinin pürüzsüz geçmesi için giyilebilir teknoloji malzemelerinin düzgün olarak çalışıp çalışmadığı multimetre kullanılarak kontrol edilmelidir. Multimetre'nin nasıl kullanıldığı verilen multimetre kullanım formunda detaylı olarak anlatılmıştır. Malzeme seçimi, toplanması ve kontrol edilmesi tamamlandıktan sora beşinci basamağa geçilir.
5 Çizilen Taslağa Yönelik Prototip Tasarlama	Beşinci basamak ürünün tasarlama sürecine odaklanır. Bu basamakta problemin çözümüne yönelik toplanan farklı türdeki malzemeler (giyilebilir teknolojiler- sanat ve tasarım araçları) birbirine dikilerek bir prototip oluşturulur. Eğer tasarımda keçe ya da kumaş kullanılacaksa bunlar taslak çiziminde belirtilen oranlarda kesilir ve uygun iplik kullanılarak dikilir. Kesme ve birleştirme işlemlerinin giyilebilir teknolojilerin tasarım üzerindeki konumu ve bağlantı yolları düşünülerek yapılması gerekir. Kesme ve dikme işlemi sonucunda oluşturulan tasarımın gövdesi üzerine giyilebilir teknolojiler iletken iplik kullanılarak birbirine dikilir. Elektronik devreler arasındaki bağlantı türü için etkinlikte verilen devre şeması takip edilir. Devre şemasında tasarımda kullanılacak olan devre elemanlarının birbirine nasıl dikileceği detaylı olarak gösterilmiştir. Elektronik devreleri iletken iplik ile birbirine dikerken kullanılan bağlantı yollarının birbirinden temas etmeyecek şekilde uzak olmasına dikkat edilir. Aksi takdirde kısa devre oluşur ve devre çalışamaz duruma gelir.

	Prototip tasarım oluştururken hangi malzemenin veya elektronik devrenin ilk önce dikileceği onu tasarlayan kişiye bağlı olarak değişebilir. Bu yüzden tasarımınız için hangisi daha öncelikli ise tasarlama işlemine oradan başlayabilirsiniz. Bu basamağın diğer önemli bir parçası da tasarıma sanat boyutunun katılmasıdır. Tasarımda kullanılan renk tonları arasındaki uyum ve bütünlük, tasarımdaki görsel zenginlik ve sadelik, tasarımı oluşturan parçalar arasındaki simetrik denge ve tasarımın estetik olması tasarımınızda bulunması gereken temel özelliklerdir. Prototip tasarımı esnasında tüm bu özelliklerin göz önünde bulundurulması gerekmektedir. Prototip tasarım tamamlandıktan sonra altıncı basamağa geçilir.
6 Prototip Tasarımını Kodlama	Altıncı basamak giyilebilir teknolojilerin tasarıma yönelik olarak kodlanmasına odaklanır. Elektronik devrelerin kodlanamadığı etkinliklerde bu basamak atlanarak bir sonraki basamağa geçilir. Bu basamakta kullanılan giyilebilir teknolojiler tasarımda hangi görevi ve fonksiyonu gerçekleştirecekse ona bağlı olarak kodlanır. Örneğin, kullandığınız LED'in tasarımdaki fonksiyonu iki saniyede bir yanıp sönmekse bu fonksiyonu gerçekleştirecek uygun kodu yazmanız gerekiyor. Bunu sensörler ve diğer kodlanabilen teknolojiler için de düşünebilirsiniz. Tasarımı kodlama işlemi tamamlandıktan sonra yedinci basamağa geçilir.
7 Oluşturulan Prototip Tasarımı Test Etme ve Geliştirme	Yedinci basamakta oluşturulan prototip tasarım, yani ürün test edilir ve geliştirilir. Bu basamakta taslak çizimi sürecinde planlanan ürün tasarımı ile oluşturulan prototip tasarım arasındaki benzerlikler ve farklılıklar tespit edilir. Tasarım için uygun görülmeyen ve ekleme ya da çıkartma yapılarak düzeltilebilen farklılıklar iyileştirilir. Düzgün çalışmayan elektronik devre elemanları varsa multimetre kullanılarak bağlantı noktaları test edilir ve gerekli görünen düzeltmeler yapılır. Bununla birlikte, uygun görülen sanat ve tasarım malzemeleri kullanılarak tasarım zenginleştirilebilir.

J. A Complete List of Camp Materials and Tools

Electronic Textiles (ENG-TR)	
Lilypad Arduino USB - ATmega32U4 Board	Lilypad Arduino USB
Lilypad Arduino Simple Board	Lilypad Arduino Temel Kartı
Lilypad Simblee BLE Board	Lilypad Simblee BLE Kartı
Lilypad FTDI Basic Breakout - 5V	FTDI USB-RS232 Temel Çevirici Kartı
Lilypad Coin Cell Battery Holder	Lilypad CR2032 Batarya Yuvası
Coin Cell Battery - 20mm (CR2032)	CR2032 Pil 3V
Lilypad Pixel Board	Lilypad RGB LED Modülü
Lilypad LED (6 Colors)	Lilypad LED (6 Renkli)
Lilypad Tri-Color LED	Lilypad RGB LED Modülü
Basic LED 3mm (3 Colors)	3mm LED (3 Renkli)
1W RGB Power LED	RGB Power LED – 1W
Lilypad Button Board	Lilypad Buton Kartı
Lilypad Slide Switch	Lilypad Aç-Kapa Anahtarı
Lilypad Vibe Board	Lilypad Titreşim Kartı
Lilypad Temperature Sensor	LillyPad Sicaklik Sensöru
Lilypad Light Sensor	LillyPad Isik Sensöru
Lilypad Buzzer	LillyPad Ses Sensöru
Flora Color Sensor	Flore Renk Sensörü
Pulse Sensor	Nabiz Sensoru
Laser Proximity Sensor	Lazer Mesafe Sensörü
PIR Motion Sensor	PIR Hareket Algılama Sensörü
Flammable Gas & Smoke Sensor MQ-2	Yanıcı Gaz ve Sigara Dumanı Sensörü MQ-2
Force Sensitive Resistor	Kuvvete Duyarlı Sensör
Conductive sewing thread - (Stainless Steel)	İletken İplik Bobin
Jumper Wires	Jumper Kablo
EL Panel – Blue-Red-White (10x10cm)	EL Panel – Mavi-Kirmizi-Beyaz (10x10cm)
Fiber-Optic Strands	Yandan Işıyan Fiber Kablo
Lipo Battery - 950mAh (3.7 V 1S)	3.7 V 1S Lipo Batarya 950 mAh 25C - Mbot Pili
USB Mini-B Cable	Mini USB Kablo
USB micro-B Cable	Micro USB Kablo

Digital Multimeter	Dijital Multimetre
Alligator Test Leads - Multicolored	Krokodil Kablo Renkli
Heat Shrink Kit	Daralan Makaron Kiti
Soldering Iron Set	Havya Seti
Textile and Crafting Materials and Tools (ENG-TR)	
Felts in different colors and thicknesses	Farklı Renk ve Kalınlıkta Keçeler
Normal (Polyester-Cotton) sewing thread in different colors and thicknesses	Dikiş İpi (Farklı renk ve kalınlıklarda)
Yarn (with different colors and thicknesses)	Örgü İpi (Farklı renk ve kalınlıklarda)
Needle set (small, medium, and large size)	İğne Seti
Sewing Thimble	Dikiş Yüksüğü
Ribbon (with different types and sizes)	Kurdele (Farklı türlerde ve büyüklüklerde)
Scissors with different sizes	Makas (Farkli büyüklüklerde)
Garment	Tisort
Fabric with different colors	Farklı Renklerde Kumas Parcaları
Assorted Beads	Çeşitli Boncuklar
Assorted Wood Beads	Çeşitli Tahta Boncuklar
Velvet Beads	Kadife Boncuklar
Embroidery Hoop	Nakış Kasnağı
Fiber	Elyaf
Clear Nail Polish	Tırnak Cilası
Textile Glue	Kumas Yapıştırıcısı
Glue Gun and Glue Sticks	Silikon Tabancası ve Silikon Cubukları
Japanese Glue	Japon Yapıştırıcısı
Fabric Pens	Kumas Kalemi
Felt-tip Pen	Keçeli Kalem
Tape (White and black)	Bant (Beyaz ve siyah)
Anti-Static Stainless-Steel Tweezers	Anti-Statik Paslanmaz Çelik Cımbız Seti
Steel Ruler (30cm)	Çelik Cetvel (30cm)
Precision Knife	Hassas Bıçak
Magnet Ring	Mıknatıs Halka
Magnetic Snap (2 cm)	Manyetik Çıt Çıt (2 cm)
Hot Air Gun	Sıcak Hava Tabancası
Needle Nose Pliers	Kargaburun Pense
Diagonal Cutters	Yan Keski
Plastic Zip Lock Bags (19x25 cm)	Kilitli Naylon Torba (19x25 cm)

1100 Ml Long Round Trend Storage Box	Yuvarlak Trend Saklama Kabı 1100 Ml
Plastic box – (18.4x8.8x4.5cm)	Plastik Kutu – (18.4x8.8x4.5cm)
80Lt Plastic Locked Storage Box	Plastik Kilitli Saklama Kutusu 80 Lt.
Female and Male Tailor Dummy	Terzi Prova Mankeni (Kadın ve Erkek)

CURRICULUM VITAE

Surname, Name: Şat, Mustafa

EDUCATION

Degree	Institution	Year of Graduation
MS	METU Computer Education and Instructional Technology	2013
BS	METU Computer Education and Instructional Technology	2011
High School	Yeşilyurt Vocational and Technical Anatolian High School, Malatya	2002

FOREIGN LANGUAGES

Advanced English, Fluent Kurdish

PUBLICATIONS

A. Thesis

Şat, M. (2013). *CEIT undergraduate students' perceptions and preferences of formative feedback, and the relationship of these perceptions and preferences with their learning approaches* [Master's thesis, Middle East Technical University]. https://open.metu.edu.tr/handle/11511/22747.

B. Articles in International Journals

Sat, M., İlhan, F., & Yukselturk, E. (in press). Comparison and Evaluation of Augmented Reality Technologies for Designing Interactive Materials. *Education and Information Technologies*. https://doi.org/10.1007/s10639-023-11646-3.

Sat, M., İlhan, F., & Yukselturk, E. (2022). Web Tools as Icebreakers in Online Education. Journal *of Educational Technology and Online Learning*, 5(3), 721–737. https://doi.org/10.31681/jetol.1084512.

Sat, M. (2017). Development and Validation of Formative Feedback Perceptions Scale in Project Courses for Undergraduate Students. *Journal of Education and Future, 12,* 117-135.

Alkis, Y., Kadirhan, Z., & Sat, M. (2017). Development and Validation of Social Anxiety Scale for Social Media Users. Computers *in Human Behavior*, *72*, 296-303. doi:10.1016/j.chb.2017.03.011.

Kadirhan, Z., Alkis, Y., Sat, M. & Yildirim, S. (2016). Publication Trends in Social Media: A Content Analysis. *Journal of Social Media Studies, 3*(1), 15-29. doi: 10.15340/21473366311014.

C. Conference Proceedings

Sat, M. & Cagiltay, K. (2022, July 1 – 4). *The design of educational wearable technologies with teachers: Issues, challenges, and suggestions* [Conference presentation]. The 22nd IEEE International Conference on Advanced Learning Technologies (ICALT 2022), Bucharest, Romania.

D. Conference Presentations

Sat, M. & Cagiltay, K. (2020, Apr 17 – 21). *Steam-Powered Activities for Middle School Science Teachers: A Design and Development Research* [Roundtable Session]. American Educational Research Association (AERA) Annual Meeting, San Francisco, CA http://tinyurl.com/yx7mk4dj.

Alkis, Y., Kadirhan, Z. & Sat, M. (2016, April 8 – 12). *Development and Validation of Social Anxiety Scale for Social Media Users* [Conference presentation]. Paper presented at *American Educational Research Association (AERA) 2016 Annual Meeting*, Washinton, D.C.

Sat, M., Alkis, Y. & Kadirhan, Z. (2015, May 20 – 22). *Development and Validation of Formative Feedback Perceptions Scale* [Conference presentation]. 9th International Computer & Instructional Technologies Symposium, Afyonkarahisar, Turkey.

Alkis, Y., Kadirhan, Z. & Sat, M. (2015, May 20 – 22). *Effects of Virtual Learning Environments on Students' Enhancement of Spatial Thinking* [Conference presentation]. 9th International Computer & Instructional Technologies Symposium, Afyonkarahisar, Turkey.

Kadirhan, Z., Sat, M. & Alkis, Y. (2015, May 20 – 22). *A Content Analysis of the Studies in education area in Turkey* [Conference presentation]. 9th International Computer & Instructional Technologies Symposium, Afyonkarahisar, Turkey.

Sat, M. & Can, G. (2015, April 16 – 20). *Perceptions And Preferences For Formative Feedback: Relationship With Learning Approaches* [Conference presentation]. American Educational Research Association (AERA) Annual Meeting, Chicago, Illinois.

Sat, M., Kol, M., Kayaduman, H. & Baran, E. (2014, November 4 – 8). *The Impacts of TPACK Workshop in Professional Experiences and Attitudes of In-Service Math Teachers* [Conference presentation]. Association for Educational Communications and Technology (AECT) *Convention*, Florida, Jacksonville.

Sat, M. & Cagiltay, K. (2014, May 20 – 22). *A Review of Feedback Practices in Distance Education* [Conference presentation]. Instructional Technologies and Teacher Education Symposium (ITTES), Afyonkarahisar, Turkey.

Ilhan, F., Sat, M. & Can, G. (2014, May 20 – 22). *Turkiye'de Yapilan Tez-Inceleme Calismalarinin Analizi ve BOTE Tez-Inceleme Calismalarindaki Egilim [The Analysis of Thesis-Review Studies in Turkey and Trends in CEIT Thesis-Review Studies]* [Conference presentation]. Instructional Technologies and Teacher Education Symposium (ITTES), Afyonkarahisar, Turkey.

Sat, M. & Can, G. (2013, June 6 – 8). *CEIT Students' Perceptions and Preferences for Formative Feedback on Term Projects: Relationships with Learning Approaches* [Conference presentation]. 7th International Computer & Instructional Technologies Symposium, Erzurum, Turkey.

E. Awards Received

IEEE TCLT Student Award, The 22nd IEEE International Conference on Advanced Learning Technologies (ICALT), 2022.