AN EXAMINATION OF STEAM TEACHER COMPETENCIES

by

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Submitted to the Institute for Graduate Studies in
Science and Engineering in partial fulfillment of
the requirements for the degree of
Master of Science

Graduate Program in Secondary School Science and Mathematics Education

Boğaziçi University

2019

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DATE OF APPROVAL: 03.09.2019

ACKNOWLEDGEMENTS

First and foremost, I would like to thank to my advisor, Serkan Özel, Ph. D. I am very grateful for everything he did. In every stage of this journey, his mentoring and friendship strengthened my abilities. I cannot express my thanks with the words I know, but still, special and endless thanks to my mother Fatma Gönül Yedekkesici, my father Burhan Yedekkesici, my husband Ahmet Beşkese, my daughter Elif Gökçe Beşkese and my son Ömer Ünal Beşkese. I would like to thank to my jury members Mehmet Aydeniz, Ph.D. and Fatih Çağlayan Mercan, Ph.D. for their recommendations. My special thanks to my doctor Burak Alptekin for his health and nutrition consultation, my friends Emine Paşahan Özkundakçı, Betül Horozal, and Dr. Ebru Arıtürk for their concentration advices and supports. The members of Discovering Families, Reyhan Egrin, Rabia Habiboğlu, Namık Kurar, Burcu Tanur, Melek Budak, Tuba Us and Esin Karaca have always been supportive and helpful, thank you so much! I would also like to thank to Ayşe Nur Karakuş, and Hatice Nur Keskin for their technical support.

Over all what I have said so far, I would like to thank Allah (God) for giving me the opportunity and strength to live and accomplish this highly educative process.

ABSTRACT

AN EXAMINATION OF STEAM TEACHER COMPETENCIES

The purpose of this study was to investigate how STEAM teachers conceptualize, define, and actualize what it means to be a STEAM teacher. A phenomenological research which is one of the qualitative methods was followed. A literature review, field visit (to one of the best STEM schools in Istanbul) and four pilot studies were completed to design in depth, semi-structured interview questions that served the two research questions; "How do STEAM teachers conceptualize the STEAM teacher competencies?" and "How do STEAM teachers define the differences between ideal teacher competencies and STEAM teacher competencies?". Five teachers from USA with at least two years of experience as a STEAM teacher were interviewed. Respondents' resumes and STEAM teacher competency mind maps were used for triangulation. Hierarchical Focusing Method was followed to receive interviewees' prominently conceptualized STEAM teacher competencies. Rapid Identification of Themes from Audio Recordings (RITA) method was utilized to capture the facial expressions and tones that reflected the sense of importance of the competency the interviewee was talking about. As a result, one hundred and thirty-nine abilities, characteristics and skills were listed as the STEAM teacher competencies and twenty eight abilities, characteristics and skills were recorded as the differences between ideal and STEAM teacher competencies. "Collaborating with Colleagues", "Collaborating with Professionals", "Life-long Learner", and "Creator and Innovator" were declared the most for STEAM teacher competencies. "Integrating Concepts", "Appreciating Arts" and "Having various Hobbies" were highly mentioned STEAM teacher competencies which ideal teachers might not necessarily possess.

ÖZET

STEAM ÖĞRETMEN YETERLİKLERİNİN İNCELENMESİ

Bu çalışmanın amacı, STEAM öğretmenlerinin, STEAM öğretmeni olmaya nasıl anlamlar verdiğini, tanımladığını ve gerçekleştirdiğini incelemektedir. Kalitatif yöntemlerden fenomenolojik araştırma metodu kullanılmıştır. İki araştırma sorusuna; "STEAM öğretmenleri, STEAM öğretmen yeterliklerini nasıl tanımlıyorlar?" ve "STEAM öğretmenleri, ideal öğretmen yeterlikleri ile STEAM öğretmen yeterlikleri arasındaki farkı nasıl tanımlıyorlar?" hizmet etmek üzere tasarlanan detaylı ve yarı yapılandırılmış röportaj sorularının hazırlanması için literatür taraması, saha ziyareti (İstanbul'daki en iyi STEM okullarından birine) ve dört pilot çalışması yapılmıştır. En az iki yıl deneyimi olan beş Amerikalı STEAM öğretmeniyle röportajlar gerçekleştirilmiştir. Yanıt verenlerin özgeçmişleri ve çizilen STEAM öğretmeni zihin haritaları nirengi (üçgenleme) için kullanılmıştır. Röportaj sorularını yanıtlayanların, herhangi bir hatırlatma olmadan STEAM öğretmen yeterlikleri hakkında düşüncelerini alabilmek için Hiyerarşik Odaklanma Yöntemi adımları takip edilmiştir. Röportajı veren kişinin bahsettiği yeterliğin önemini belirlemek için yüz ifadeleri ve ses tonunun değerlendirildiği Ses Kayıtlarından Süratli Tema Belirleme (RITA) yönteminden yararlanılmıştır. Sonuç olarak, STEAM öğretmen yeterliliği için yüz otuz dokuz tane yetenek, beceri ve özellik listelenmiştir. İdeal ve STEAM öğretmen yeterliği arasında yirmi sekiz farklı yetenek, beceri ve özellik kaydedilmiştir. "Çalışma Arkadaşlarıyla İşbirliği", "Uzmanlarla İşbirliği", "Hayat Boyu Öğrenme" ve "Orijinal Fikir Üretme ve İnovatif Olma" , öğretmenler tarafından en fazla bahsedilen ve önem verilen STEAM öğretmen yeterlikleridir. "Kavramların Entegrasyonu", "Sanata Değer Vermek" ve "Çeşitli Hobilere Sahip Olmak" ideal öğretmende bulunmayabilecek fakat STEAM öğretmeninde olması gerektiği belirtilen özelliklerdi.

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LIST OF SYMBOLS

M	Mind Map
R	Resume
+	Enthusiastic Expression
●	Said without prompt

LIST OF ACYRONYMS / ABBREVIATIONS

MRI	magnetic resonance imaging
fMRI	functional MRI
PET	positron-emission tomography
STEM	Science Technology Engineering Mathematics
STEAM	Science Technology Engineering Arts Mathematics
PD	Professional Development
SMET	Science, Mathematics, Engineering and Technology
NSF	National Science Foundation
K-12	From Kindergarden to 12^{th} Grade
WWII	World War II
NASA	National Aeronautics and Space Administration
EI	Emotional Intelligence
5E	Engage, Explore, Explain, Extend (Elaborate), Evaluate
HFM	Hierarchical Focusing Method
RITA	Rapid Identification of Themes From Audio Recordings

1. INTRODUCTION

It is not just we are doing great science but we are talking about being great humans.
Cynthia Burt (Brandy, 2014)

One of the crucial problems that almost every parent and every teacher face at least once in their life is when their children and students refuse going to school (Willingham, 2009). One of the several reasons is finding no meaning in just memorizing facts that they forget the next day (Phelan, Davidson, & Cao, 1992). Students claim that subjects are not engaging, lessons are boring (Garcia & Pacheco 2013; Hughes & Read 2018), sitting on uncomfortable chairs quietly throughout the day is distressing (Kizilçelik, 2015; Reilly, 2018). In short, students are unsatisfied and do not want to experience these negative feelings during school hours, which fill up most of the day (Göksoy, 2017). Unfortunately, the term – learning – is easily associated with negative feelings, which results in forming barriers towards long life learning. Rumberger (2001) reports, 77% of dropouts are school-related. The education system and multiple-choice tests mostly focus on whether the students are successful in retrieving the stored information. The emotions, needs, beliefs, and wills of students are generally ignored, which is "against human nature" (Jensen, 2008, p. 4).

Despite the fact that many aspects of the brain still remain undiscovered; the efforts on understanding its processes have released valuable clues on how the brain learns naturally. High technologies, such as magnetic resonance imaging (MRI), functional MRI (fMRI), and positron-emission tomography (PET) (Hawn, 2011; Jensen, 2008; Willis, 2007a), have enabled us to go further than ever in analyzing the functions of the brain. The most important discovery that will help educators is that information is stored in the brain with the emotions attached to it (Kwik, 2018). In other words, positive feelings, like happiness makes it easy to store the information to the long-term memory (Jensen, 2008) giving the healing signal "learning is fun". Similarly, negative feelings, such as boredom, makes it hard or even impossible to retrieve the information (Kwik, 2018; Stolk, Zastavker, Dillon, & Gross, 2016). A strong state of emotion (negative or positive), enhanced motivation, especially interesting context, and increased attention can retrieve the event or the information easier (Willis, 2007b). The important question here is, "Does the treatment

make the individual a lifelong learner or not?" Positive feelings may urge the desire to explore and learn more about a subject, but negative feelings may inhibit the willingness to search and acquire further knowledge (Christianson, 2014).

The feeling of happiness is experienced when the brain releases neuro-transmitting hormone-dopamine (Green & Achor, 2010; Grison, Heatherton, & Gazzaniga, 2017; Wise 2004). "*Engaging in physical activities such as sports, dance, and play; making choices and solving problems, collaborating with peers, enjoying creative efforts and disciplines such as music, art, drama, reading, and storytelling, participating in acts of kindness*" are some of the activities that increase dopamine release (Hawn, 2011, p.10). Science Technology Engineering Arts and Mathematics (STEAM) education philosophy covers almost all of the activities listed above (Wynn & Harris, 2012). It is an approach to teaching and learning that integrates the content and skills of science, technology, engineering, arts and mathematics. This kind of teaching would support reform instruction and learning in the 21st century classroom well (Ames, Reeve, Stewardson, & Lott, 2017). Real life problems are at the center of STEM and STEAM education (Aydeniz & Hodge, 2015; Özel, 2013) that follows engineering steps for alternative solutions presented with technology, in science and mathematics. STEAM teaching and learning integrates information in place-based projects accessing everyday technology of virtual field trips, digital interactives, apps, and contemporary art, science and design practices. STEAM by Design develops designing and creating minds (Keane & Keane, 2016).

STEM/STEAM education is likely to help students become innovative, creative, critical thinker, good communicator, good collaborator, flexible, adaptable problem solver. These are the most important characteristics that almost all the companies are looking for before hiring their personnel. Therefore, in order to have a successful STEAM education STEAM teacher education should be designed carefully. The first step in designing a PD program is to determine the competencies of STEAM teachers. This study focused on STEAM teacher competencies by using phenomenological research which is one of the qualitative methods. The results are given as a list.

2. LITERATURE REVIEW

2.1. Human Learning

Attracting students' attention is one of the key concepts in teaching (Wolfe, 2010) because willingness to learn prepares the brain to receive and store information to long-term memory. If a positive feeling accompanies with this complement, then remembering that information becomes easier. Since human beings constantly yearn to experience positive emotions, whenever a positive feeling is attached to information, it can be easily recalled. (Scalise & Felde, 2017, p. 168) However, if a person is facing a sad, scared or stressed emotion while storing the information then she/he does refuses to remember because the stored information triggers the negative emotion (Jensen, 2008; Willis, 2007a). Thus, it can be stated that the learning environment should be designed with the aim to appeal to the student's positive emotions in order to make them content and motivated during the learning processes.

The feeling of happiness is experienced when the brain releases neuro-transmitting hormone-dopamine (Grison, Heatherton, & Gazzaniga, 2017). "*Engaging in physical activities such as sports, dance, and play; making choices and solving problems, collaborating with peers, enjoying creative efforts and disciplines such as music, art, drama, reading, and storytelling, participating in acts of kindness*" (p. 10) are some of the activities that increase dopamine release (Hawn, 2011). Studies (Warner & Vroman, 2011; Willis, 2007a; Winter, 2011) have shown that activities such as exercising, laughing, playing, and listening to stories read aloud makes the brain release more dopamine. Other examples include activities that require investigation and exploration, cooperative learning, allowing students to determine their own learning goals, allowing students to freely choose subtopics to investigate, social collaboration, and physical activity related to academic study. Willis (2007a) explains this process as follows:

> *Neuroimaging brain research demonstrates that superior learning takes place when classroom experiences give active voice to students. Positive motivation impacts brain metabolism, conduction of nerve impulses through the memory filters, and the release of neurotransmitters that increase executive function and attention. When curriculum is relevant*

> *to students' lives, interests, and experiences, and students feel that they are partners in their education, they are engaged and motivated. During periods of high stress or anxiety, functional MRI studies show increased blood flow to this "emotional" portion of the limbic system. When the amygdala is in this hyperexcitable state, neural activity through the amygdala to the higher learning and association centers in the rest of the brain is profoundly reduced. (p. 23)*

Basic psychological needs and meaning in life are fundamental core variables that contribute to happiness. (Demirbas-Celik, 2018) determines the four factors that affect the happiness of students in the classroom: (a) competence, (b) relatedness, (c) autonomy, and (d) meaning in life. Having a hobby, helping others and chatting with friends are powerful factors in explaining life satisfaction. In another study, pursuing life goals has been determined as an important factor for happiness (Cihangir-Çankaya & Meydan, 2018). When learning accompanies with strong positive emotions, that is when dopamine is released, the effect is greater and information is stored in the memory longer. On the other hand, when stress and anxiety are present, learning is blocked by the physical process of the brain.

Another important situation when dopamine release takes place, is giving the appropriate feedback to the students (De Vries, Ulte, Zwitserlood, Szymanski, & Knecht, 2010). De Vries and her colleagues (2010) mention the importance of providing feedback. In their research they showed

> *...that increasing dopamine levels in the brain improves the gradual acquisition of complex information in healthy participants. We implemented two artificial-grammar-learning tasks, one with and one without performance feedback. Learning was improved after levodopa intake for the feedback-based learning task only, suggesting that dopamine plays a specific role in trial-by-trial feedback-based learning. (p. 3193)*

Thus, integrating these activities to the lessons will make learning easy, fun and long lasting. Brain research have put forward that deep and long term learning is acquired when the individuals are exposed to real life experiences in the learning environment (Yalçin, Yalçin, Akar, & Sagirli, 2017). Meanwhile, effective communication is established with the beneficial guidance of learners through their learning process (Rogers, 1994). Innate motivation is evoked by active engagement, which is essential for deep learning (Ozden &

Gultekin, 2008). Encouraging curiosity by appealing to students' interest and understanding their strengths, with the aim to provide a chance to use them while connecting the new information to the previous knowledge, evokes the childhood passion for learning. Thus, in order to conceive the new subject easily, engaging, creative and flexible lesson plans should be designed (Coulthard *et al.*, 2012).

Among different education philosophies, STEM (Science, Technology, Engineering, Mathematics) appeals to be an appropriate philosophy that may involve the aforementioned factors that affects deep and long-term learning (Akgündüz *et al.*, 2015). STEM education philosophy builds a well-designed learning atmosphere involving necessary conditions constructed by clear and structured goals that the students experience the joy of exploring life. STEM education is defined as "approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects" (Sanders, 2008, p. 21). STEM education includes the knowledge, skills and beliefs that are collaboratively constructed at the intersection of more than one STEM subject area (Corlu, Capraro, & Capraro, 2014).

Real life problems are also at the center of STEM education (Aydeniz & Hodge, 2015; Özel, 2013) that follows engineering steps for alternative solutions presented with technology, in science and mathematics. There is developing relationship between science and arts. Some researchers propose that science learning is not complete without the arts. The drivers of STEAM (Science, Technology, Engineering, Arts, and Mathematics) add new dimensions to the nature of science and make science diverge rapidly from school science. The result could be a more authentic and engaging school science, one more relevant to the needs of the twenty-first century (Braund & Reiss, 2019). STEAM philosophy highlights the importance of STEM education, but argues that "the arts have the ability to open up new ways of seeing, thinking, and learning" (Ghanbari, 2015). It offers an effective atmosphere for problem solving, collaboration, communication, creativity and critical thinking, which are described as core skills leading to lifelong success (Riley, 2019). The end result will be innovators, problem solvers, leaders, planners, team workers, educators and learners (Perignat & Katz-Buonincontro, 2019). STEM projects including arts improve creativity and innovation and STEAM is perceived

as the next step after STEM applications (Bécar, Vareille, Cayez, & Notteau, 2017; Riley, 2019).

"There is a trend in contemporary art to conceive of artmaking as a social practice. While art as social practice may trace its aesthetic roots to John Dewey's Art as Experience (1934), recent scholars have also called for art to become a critical component of social life" (Guyotte, Sochacka, Costantino, Walther, & Kellam, 2014). STEAM teaching and learning integrates information in place-based projects accessing everyday technology of virtual field trips, digital interactives, apps, and contemporary art, science and design practices. STEAM by Design develops designing minds" (Keane & Keane, 2016).

Turkish Ministry of Education is motivating and supporting teachers to design STEM activities at school, across the city and the country (Koştur, 2017). In-service training is essential (Mercan, 2015) to satisfy the urgent demands of the world for STEM jobs. Careers in STEM/STEAM fields are raising three times faster than jobs in other fields and there is an urgent need for innovative minds that can think out of the box. It is recorded that most of the scientific geniuses lived between 1902 and 2005 were not only competent in science but also in the arts (Land, 2013). It is difficult to predict the future needs and working areas of people, but some may foresee occupations like astronautic geologists, biomimicry analysts, quantum linguists, medical mathematicians, or crypto-privacy engineers (Land, 2013) who must have a holistic, multidisciplinary and visionary mind (Wynn & Harris, 2012).

Schools are the venues that prepare students for their future lives. Thus, we need well designed STEAM lesson plans that will most probably prepare students for future life demands. Learning the artistic view would lead to flexible thinking, risk-taking, exploration and making inevitable mistakes (Dwek, 2015). These mistakes are important because they will boost the brain and force it to find outrageous solutions with the power of perseverance through failure (Perignat & Katz-Buonincontro, 2019).

Complicated systems and problems require higher creative skills. Integrating arts and science produces a unique skill set that can develop unpredictable outcomes. "Having the ability to simultaneously decompose a complex problem using convergent thinking and

then apply the corresponding solution to the real world uses divergent thinking." (Khine & Areepattamannil, 2019, p. 4) Mathematics, science and engineering fields serve for convergent thinking and arts serve for divergent thinking (Bazler & Van Sickle, 2017; Land, 2013; Payton, White, & Mullins, 2017). Including arts into the STEM curriculum would give the students the opportunity to build their own understanding of life and self-motivation.

Studies have shown that creative people are generally trained in multiple disciplines (Rackauckas, Schilling, & Nie, 2018). Root-Bernstein (2015) gives four types of evidence for this:

> *First, STEM professionals themselves argue that beyond verbal and mathematical skills, success requires a vivid visual and spatial imagination; hand–eye coordination and manipulative ability; skill with making and interpreting models; and a highly developed aesthetic or artistic sensibility. Second, controlled statistical studies of large groups (hundreds to thousands) of STEM professionals reveal strong correlations between artistic, musical, literary and crafts activities and measures of success in STEM subjects such as Nobel Prizes, numbers of patents or companies founded. Third, STEM professionals involved in these statistical studies themselves can describe specific ways in which their avocations stimulate their vocational successes. And fourth, many of these specific stimuli (such as improved observational and visual thinking skills, manipulative skills and tool use, and improved learning and retention strategies) also improve STEM learning in well-controlled classroom trials. The knowledge and skills required to be professionally creative are, in short, learnable. (p. 205)*

Companies are longing for this astonishing innovation that will help them compete in the vicious competition. (Vareille, 2008) STEAM is promising this creativity building with all the successful factors it involves. Teachers play the most critical role in nations progress by giving future generations a great vision of the successful and peaceful world. (Scalise & Felde, 2017; Spillane, 2015) Teachers are the main actors (Türkmen, 2014) of the school experiences that literally shape the minds through the biological properties of neural plasticity (Scalise & Felde, 2017). Teacher student relationship is the crucial factor in the successful application of the education systems (Hosan & Hoglund, 2017; Konishi, Hymel, Zumbo, & Li, 2010). Recent research mostly reports that teacher experiences have a clear-cut effect on students' improvement in the learned subjects. (Kukla-Acevedo, 2009)

The experiences go back to their training years at university and onwards. Well-equipped teachers would be more effective in finding unique solutions to educational problems (Özel & Özel, 2013).

Apparently, ideal teachers should be lifelong learners in order to continuously feed the student's needs and find brilliant ways to design the perfect learning environments for all types of students. Türkmen (2014) refers to teacher traits that affects a student's success, such as being cheerful and an expert on the subject, having a sense of humour and the ability to empathize with them.

Ideal, good, and best teacher definition is made by many researchers. (Allgood, 2003; Arnon & Reichel, 2007; Christensen,1999; Crabtree, 2017; Delso, 1993; DiGrazia, 2018; Garlick, 1991; Haleck, 1997; Hansen, 1991; Kennedy, 1997; Newman, 1993; Onwugbenu, 2013; Özkan & Arslantaş, 2013; Pyne, 2006; Sanchez, 2007; Smith, 2004; Strader, 2009; Thorner, 2017). Although there are many studies on good, best, and ideal teachers' characteristics, there are few studies on STEM teacher characteristics (Grier & Johnston, 2009; Slavit, Nelson, & Lesseig, 2016; Spillane, 2015) and two researches on STEAM teacher characteristics (Kim & Bolger, 2017; So, Ryoo, Park & Choi, 2019) to the best knowledge of the researcher.

Many countries designate the importance of STEM and STEAM applications in education (Jho, Hong, & Song, 2016). Despite the increasing interest toward STEM and STEAM education, what constitutes teachers' competency in STEM and STEAM education is not well understood (Honey, Pearson, & Schweingruber, 2014). Concerning the issue of teachers' STEM and STEAM competency, Honey and friends argue that little is known from the existing research about ''how best to support the development of educator expertise'' (p. 115) in STEM and STEAM education.

This study was established to investigate and examine STEAM teacher competencies. Researcher believes that the first step in designing an effective Professional Development (PD) is to determine the outputs of the program well, so an in-depth, semi structured interview questions were established to serve for this phenomenological qualitative study.

2.2. STEM Education

The acronym STEM represents an ostensibly simple list of four disciplines - Science, Technology, Engineering and Mathematics - but it has come to serve as a complex concept linking education approach that effects widely employment and productivity. It is used by a broad range of interest groups with different schedules, such as education providers, industries, governments, and the media. Different perceptions exist in education and workforce planning, which lead to different goals and implementation systems (Siekman, 2006).

Researches on conceptualization of STEM declare that the definition is not common for all STEM experts. Their points of view are dependent on the area of expertise and how they experience STEM in their daily lives. From teachers' perspective, introduction to STEM can be numerous hands on activities, but in general, it is a student centered project based learning which is replaced with lecturing. To some, it is called STEM when science, technology, engineering and math curricula are integrated which is similar to the work of a scientist or an engineer. To others, STEM is a promotion for having more graduates on science, technology, engineering, and mathematics areas. In the end, the question remains unanswered: What is STEM (Breiner, Harkness, Johnson, & Koehler, 2012)?

STEM is an acronym for the disciplines of science, technology, engineering, and mathematics taught and applied either in a conventional and discipline-specific manner or through a multidisciplinary, interconnected and integrative approach (Hom, 2014; Siekmann, 2016). Both approaches aim to solve real-world problems. STEM education and training builds relationships between the four disciplines with the objective of improving individual's skills by supporting technical and scientific education with a strong emphasis on critical and creative-thinking abilities. (Siekmann, 2016)

The important abilities based on economics and psychology literature, and a global meta-analysis on the skills required by employers describes four skill sets (Siekmann, 2016):

1. socioemotional (e.g. resilience)
2. basic cognitive (e.g. numeracy)

3. higher-order cognitive (e.g. critical thinking)
4. technical skills (e.g. coding).

Mostly required skills by employers are higher-order cognitive skills and socioemotional skills (Siekmann, 2016).

Today, the STEM acronym is widely used in various contexts and has come to be recognized as an integration of formerly separate subjects into a new and coherent field of study. National Science Foundation (NSF) prefers to explain STEM fields broadly, including not only the core subjects of mathematics, natural sciences, engineering, and computer and information sciences, but also such social/behavioral sciences as psychology, political science, sociology, and economics (Breiner *et. al.,* 2012).

STEM is the roof covering the constitution, which is based on a foundation of skills needed for everyday life, such as literacy and numeracy. To succeed at all levels of education and employment, self-efficacy is supported by socioemotional skills, such as curiosity and flexibility. Further rooms are separately occupied by advanced cognitive skills, such as critical and creative thinking and technical, occupation or discipline related skills. (Siekmann, 2016)

STEM is a specific program designed for a specific purpose – to integrate and apply knowledge of math and science in order to create technologies and solutions for real world problems, using an engineering design approach (Quigley and Herro, 2019). Students demonstrate greater motivation and involvement, as well as learn more deeply, when they can apply classroom-gathered knowledge to authentic problems, and also when they take part in problem solving that requires sustained engagement and collaborative activities (Barron & Darling-Hammond, 2008).

STEM is the purposeful integration of the various disciplines as used in solving real-world problems. This STEM education perspective involves viewing the separate disciplines of science, technology, engineering, and mathematics as one unit, thus teaching the integrated disciplines as one cohesive entity. STEM professionals naturally practice

integrated STEM and are less likely to separate disciplines as seen in the typical school subjects of chemistry, physics, math, or English (Breiner *et. al.*, 2012).

STEM teachers ask students to make extra relationships, not only between the STEM subjects but also with other knowledge, ideas, and concepts that they bring into the classroom. Vasquez, Sneider and Comer (2013) propose that the four STEM fields are best taught, learned, and assessed holistically, rather than as separate, unrelated subjects. Prior research has shown that involving students in such an integrated curriculum can improve their interest and motivation for STEM (Thibaut, Knipprath, Dehaene, & Depaepe, 2018). Nonetheless, the implementation of a new instructional approach, such as iSTEM, is not straightforward and to optimally profit from its possible benefits, it is important that teachers understand the iSTEM philosophy deeply and apply effectively.

2.3. STEAM Education

STEAM includes arts, which is not limited to the visual arts but also involves music and drama (Bazler & Van Sickle, 2017). Broader explanation of arts would be; music, rhythm, theatre, drama, dance, poetry, writing, visual arts and media arts. STEAM integrates arts with STEM giving opportunities for diverse learners without fear. 21st century searches for problem solvers, creative and critical thinkers. STEAM makes it possible not only for the individuals preferring to work at STEM jobs, but for all students.

Art and science are alike in the sense of discovery and exploration. They promote curiosity, require observation to provide accuracy and build atmospheres for good communication and collaboration. Integration of content areas with the arts makes teaching enjoyable, develops cognitive thinking and improves long term memory (Sousa & Pilecki, 2018). The arguments on reasons of teaching STEAM but not STEM are as follow;

- Enhance cognitive growth,
- Enhance emotional growth
- Enhance psychomotor growth,
- Promote creativity
- Improve long-term memory

- Engage young brain
- Make teaching more interesting
- Reduce stress
- Introduce novelty
- Advance social growth

Sousa and Plecki (2018) describe art as a collection of skills and thought processes that transform all areas of human engagement. The arts improve cognitive abilities and prepare individuals for the demand of the twenty-first century. Elliot Eisner, professor at Stanford University, identifies the important eight competencies:

- "The perception of relationships
- An attention to nuance
- The perspective that problems can have multiple solutions, and questions can have multiple answers
- The ability to shift goals in process
- The permission to make decisions in the absence of a rule
- The use of imagination as the source of content
- The acceptance of operating within constraints
- The ability to see the world from an aesthetic perspective" (Sousa & Plecki, 2018, p.16)

Recording the brain's electric signals (electroencephalography, EEG), researchers discovered that children intensively focus on the activity while performing arts and this condensed attention improved cognition. In addition, the arts often involve strong feelings, and such powerful emotions enhance cognitive processing and long-term memory (Sousa & Plecki, 2018). Since information is stored in the brain with the emotions attached to it (Kwik, 2018), positive feelings, like happiness makes it easy to store the information to the long-term memory (Jensen, 2008) giving the healing signal, *learning is fun.*

STEAM education makes it possible to enjoy studying science, mathematics and other disciplines that students struggle by using music, dance, drama, painting or other components of art (Segarra, Natalizio, Falkenberg, Pulford, & Holmes, 2018)

STEAM educational approach promoted in Korea, have great potential to increase student engagement and learning. Many pre-service teachers saw creative or big-picture thinking as a distinct advantage of creating and using STEAM lesson plans (Kim & Bolger, 2017).

STEAM education is more than just building aesthetic structures. It is a way of teaching children how to look at from different angles in order to produce numerous creative solutions to various kinds of problems (Costantino, 2018). It is a way of getting prepared for the life after high school (Sousa & Pilecki, 2018). It is a way to feel, taste and live the real beauties of life. It is a good way of becoming great humans (Brandy, 2014).

2.4. Statement of the Problem

Over the next decade, the demand for scientists and engineers is expected to grow four times (Sublette, 2013). Integrating science, technology, engineering and mathematics disciplines was a strategic decision made by scientists, technologists, engineers and mathematicians to incorporate forces and build a strong political path (Force, 2014). The critical role of STEM education was emphasized in reforming the economy and sustaining innovation (English, 2015). The plan involved the following objectives; increasing STEM interest and engagement among the public of all ages; increasing opportunities to develop deeper STEM knowledge, skills, and abilities; improving STEM educator and leader preparation; improving the institutional capacity to support effective STEM education and learning programs; and increasing the STEM learning base and use of evidence based STEM education practices (Marginson et. al., 2013).

Nevertheless, number of students seeking careers in science, technology, engineering and mathematics is decreasing (Stevenson, 2014). Researchers trying to find the causes of this lack of interest in STEM fields have discovered that many science teachers today are still using 19th century teaching methods. (Sublette, 2013). Since teachers have the most

important role in applying effective education systems, they have to be trained well (Ames *et. al.*, 2017; Bridges, 2014; Buddin & Zamarro, 2009; Chu *et al.*, 2015; Clotfelter, Ladd, & Vigdor, 2007; Clotfelter, Ladd, & Vigdor, 2010; Hanushek, 2011; Harris & Sass, 2011). It is hard for the teachers to fully change their practices immediately without continuous guidance (O'Neill, 2012). Therefore, a well-designed STEM PD program that will support the ambitious teachers is needed.

There are many different STEM PD programs mentioned in literature (Avery & Reeve 2013; Brenneman, Lange & Nayfeld 2019; Herro & Quigley 2017; Kirchhoff & Lawrenz 2011; Shernoff, Sinha, Bressler & Ginsburg 2017; Spillane *et al.*, 2015; Sublette, 2013). However, the first step in designing a PD is to determine the goals of the education program (Dashwood, 2019). Before designing STEM or STEAM PD programs, it is necessary to determine the training outputs, namely STEM or STEAM teacher competencies. Unfortunately there are few studies available that focuses on educators teaching STEM disciplines (Lucietto, Russell & Schott, 2018). In literature, there are six studies on STEM teacher competencies (Ames *et. al.*, 2017; El Nagdi, Leammukda & Roehrig, 2018; Slavit, Nelson & Lesseig, 2016; Song, 2017; Spillane, 2015; Srikoom, Faikhamta, & Hanuscin, 2018) and three research on STEAM teacher competencies (Kim & Bolger, 2017; Kim & Kim, 2016; So, Ryoo, Park & Choi, 2019) to the best knowledge of the researcher. In addition, comparisons between ideal teacher competencies and STEM or STEAM teacher competencies were not found in literature.

2.5. Purpose of the Study

This study aimed to investigate STEAM teacher competencies, their priorities and differences between ideal teacher competencies. A detailed list of characteristics of STEAM teachers put in order of priority was established (Figure 5.1.). The differences list between ideal and STEAM teacher competencies put in order of preference was formed (Table 5.3.).

2.6. Research Questions

The following research questions guided this qualitative study:

RQ1: How do STEAM teachers conceptualize the STEAM teacher competencies?

RQ2: How do STEAM teachers define the differences between ideal teacher competencies and STEAM teacher competencies?

3. TEACHER COMPETENCIES

Competence is the ability to execute a specified job function or responsibility stated in standards determined by the authority. If a person is competent, it means that she/he satisfies the people with the performance she/he puts forward (Naumescu, 2008). Ismail and her colleagues define competency as "the combination of knowledge, effort and experience which enable an individual to complete a task perfectly" (2018a, p.138).

A competence is a description of something which a person who works in a given occupational area should be able to do. It is a description of an action behaviour or outcome which a person should be able to demonstrate. (Rahayu, Ulfatin, Wiyono, Imron, & Wajdi, 2018)

Teachers take the most important responsibility of being a role model (Asrar-ul-Haq, Anwar, & Hassan, 2017) to students, parents and society. They have the greatest power of changing people's lives by gradually improving their skills and attitudes in a building manner (Ministry of Education Republic of Turkey, 2017, p. 1). Since teachers are the most critical component (Slater, Davies, & Burgess, 2012; Strong, 2011) of the education system as innovators, designers and professionals of education, their competencies should be carefully determined and listed in detail.

Fundamentals of teaching and learning are changing because of rapidly changing technological tools and advices. Decades ago, teachers were the only experts of knowledge to a receptive audience, giving lectures to students who were expected to listen quietly, take notes, memorize and retrieve information whenever it is asked. Today, teaching involves personalization, innovative teaching techniques, team activities, authentic and student-centered learning, and positive relationship between the teacher and students (Allgood, 2003).

There are different classifications of teacher competencies reported in literature because every researcher has a unique criterion but the general grouping that is involved in all of the groundwork involves; knowledge, skills and attitudes. Detailed descriptions and

investigations of the development of each item will be a useful guide for success seeking teachers to become an effective teacher (Moghtadaie & Taji, 2018).

3.1. Ideal Teacher Competencies

Ideal teacher competencies consist of being good at content subject knowledge, and pedagogical process knowledge, knowing students' abilities and selecting learning tools accordingly, performing effective communication skills, building good interpersonal relationships, having positive attitude and characteristics (Ismail, Don, Husin, & Khalid, 2018a).

The factors describing an ideal teacher have different effects on the success of the teacher. A recent study on finding the contribution of each item on the teachers' professional competencies stated that personal characteristics (0.5) have the most impact on the effectiveness of the learning process. Skills (0.4) and attitude (0.4) of the teachers have the second important effect on the success of the teachers' performance. Ability has the third and knowledge has the forth place according to correlation coefficient values (Moghtadaie & Taji, 2018).

3.1.1. Professional Knowledge

Ololube (2006) approved that teachers having high academic competency are more strongeffective than less knowledgeable teachers. Rahayu (2018) and her friends stated that one of the seven factors signifying the effectiveness of a school is professional development of staff. The whole is greater than the sum of the parts because the impact of increasing competencies is synergistic.

3.1.1.1. Deep Content Knowledge. Deep content knowledge includes understanding the core concepts, inquiry methods, framework of the specific discipline, how to create effective learning environment and activities that will enable the learner to master the concepts (Borich, 2014). In one of the studies it was recorded that as the teachers' mathematics knowledge increase students got better results from the evaluation tests (Strong, 2011, pp. 28-29).

3.1.1.2. Deep Pedagogical Content Knowledge. “For a good teacher, teaching is like being a medical doctor, diagnosing the student’s condition and offering a remedy,” (Allgood, 2003). The heart connects teachers and students, establishing a relationship that is unlike any other. In one of the studies it was stated that pedagogical content knowledge was positively correlated with the scores students received from mathematics tests they took (Strong, 2011, p. 29).

3.1.2. General Knowledge

One of the important factors effecting students deep understanding of the defined subject is the relevance of the subject to the learner’s experiences and interests. Once the teacher gets detailed information about the students in the class, she/he tries to give examples from the subjects that attract them the most. Every year, learners change and they bring their individual preferences to the class. In order for the teacher to reach every single student, she/he has to have a broad general knowledge various subjects. These subjects may be sports, history, economy, philosophy, geology, astronomy or arts. Giving examples from different areas of study will easily attract most of the students’ attention and they will evoke the intrinsic motivation towards learning new concepts (Graham, Berman, & Bellert, 2015).

3.1.3. Professional Skills

3.1.3.1. High Emotional Intelligence (EI). According to Goleman (2005), emotional intelligence is the ability to ignite intrinsic motivation and control strong emotions like frustration. Rahayu and her friends (2018) verified that EI is the ability to feel, understand, and sufficiently apply the power of emotions as a source of limitless energy to get information, and make an impact. EI also defined as an ability to recognize one’s own feelings, motivate ourselves, and effectively manage own emotions and interpersonal relationships (Goleman, 2005).

School administrators who have high emotional intelligence do not only have a strong relationship with their peers, teachers, parents, and students but may also be

effective in leading change and initiating school reform. Van Rooy and Viswesvaran (2004) concluded that emotional intelligence can be considered a valuable predictor of work performance.

Teachers valuing their own feelings are better in expressing their needs and this helps them to reach their goals and brings success. They also tend to be more aware of others' needs and contribute emotional support to build collaboration with others to achieve an effective performance. Studies have shown that teachers who demonstrate outstanding performance have high emotional intelligence (Mohamad & Jais, 2016).

Emotional Intelligence contains the following personal skills;

(i) Self-Regard
(ii) Self-Actualization
(iii) Emotional Self-Awareness
(iv) Emotional Expression
(v) Assertiveness
(vi) Independence
(vii) Interpersonal Relationships
(viii) Empathy
(ix) Social Responsibility
(x) Problem Solving
(xi) Reality Testing
(xii) Impulse Control
(xiii) Flexibility
(xiv) Stress Tolerance
(xv) Optimism
(xvi) Happiness / Well-Being (Hughes & Terrell, 2011)

3.1.3.2. Communication. People give messages with words, their bodies, their voices and tones of voices, facial expressions and their outlook. While communicating with others, it is stated that 70% of body language, 25% tone of the voice and 5% of the words used affects the listener. Eye contact is important in giving a successful speech and building rapport between the teacher and the students (Ledbury, White & Darn, 2004).

3.1.3.3. Effective teaching. Preparation of a lesson plan is the critical issue for an effective lesson and an effective teaching. Designing a successful lesson needs thoughtful time for planning the method, activities and materials that focuses on the objectives. Strong opening of a lesson would be drawing the attention of the whole class to the determined subject by a magnet like question. This would make the students easily focus on the objects of the lesson and get curious about the coming knowledge. Fruitful questions following the opening question will lead the students to gather more information. Effective teacher would see the subject from a wide perspective and see the big picture. She/he would show the big picture to the learners. Helpful and appropriate feedback will make the students see their mistakes and the improvement areas of their activities and thoughts. The effective lessons and effective teachers would eventually establish lifelong learners. She/he creates continuous learning cultures.

3.1.3.4. Application of different learning approaches, methods, techniques. Every individual is different from the other in different aspects so teacher has to satisfy the needs of all the students in the class. Knowing all the different learning approaches, methods and techniques will empower the teacher in selecting the most appropriate method that will fit the needs of all the individuals in the class. Some of the useful methods are; Inquiry based learning, problem-based learning, project-based learning, constructivist learning, discovery (5E) learning, authentic learning, inter-disciplinary learning, peer teaching, student centered learning, active learning, multiple intelligence, mind mapping.

3.1.3.5. Creative (High Imagination) Thinker – Innovator. Lesson Planning, Implementing Learning Process, Assessment and Evaluation are the three major items mentioned in Rahayu and her friends' study on professional teacher competencies.

Teaching must be innovative and artistic; learning activities are not prescribed (Allgood, 2003). Students, especially gifted students experience social and emotional difficulties at school (Piske, Stoltz, Guėrios, Camargo, Vestena, and Freitas, 2017). Most of them complain about learning the same subjects with the same method every year which makes them get bored of learning and going to school. Students and their families are looking for innovations in education (Djebbari & Djebbari, 2018). Vygotsky gives special

importance to creativity because he argues that creativity leads people to make unbelievable inventions, outstanding discoveries, useful creations, understanding historical works and expressing real life with unique interpretations. Piske and her friends (2017) mention about creativity as being an essential factor in education and give a strong argument saying that "without this attribute, teaching is meaningless to exist" (p. 132). Some of the teachers quit job because of the repetitive and tiresome life of instruction. Creativity will serve for teachers to promote well-being and take the role of mediating students, real life and knowledge. "As Vygotsky explains, it is precisely through the mediation that is possible to develop the creative potential," (Piske *et. al.*, 2017). It will give the teacher the ability to produce something new, original, unique and unpredictable which will change the learning environment to a desired and potential evoking place. These conditions will be motivating and encouraging students to wonder and explore what is surrounding them. They need to use their creative capacity and improve it. Hence, the students satisfaction levels will rise, self-esteem will increase and self-concept will become better. If the teacher is creative then the subjects in the curriculum will be learned in a stimulating environment which will boost students' learning, understanding and success.

Contribution of teachers' innovation to school effectiveness is tremendous. A unique idea, an extraordinary technique, an outstanding practice or a remarkable object people accept to adopt would upraise the school performance and student success to an unpredictable level (Rahayu *et al.*, 2018). Three indicators of innovation are; self, task and impact. Innovation is a critical ability to invent or develop products, processes, and services.

Teacher competencies were always at the center of research throughout centuries. Most of the research tried to group the factors. Keeley, Smith, and Buskist (2006) established two categories from twenty eight items using factor analysis. The subcategories are listed in Table 3.1.

Table 3.1. Ideal Teacher Competencies (Keeley *et. al.*, 2006)

Caring and Supportive	Professional Competency and Communication Skills
Strives to be a better teacher	Confident
Provides constructive feedback	Effective communicator
Sensitive and persistent	Knowledgeable about subject matter
Rapport	Authoritative
Encourages and cares for students	Happy/Positive attitude/Humorous
Flexible/Open-Minded	Technically competent
Understanding	Prepared
Realistics expectations of students/Fair testing and grading	Approachable/Personable
Accessible	Respectful
Promotes critical thinking/Intellectually stimulating	Punctuality/Manages class time
Humble	Good listener
Enthusiastic about teaching and about topic Presents current information	Creative and interesting
Professional	
Establishes Daily and academic term goals	

3.2. Future Teacher Competencies

As technology is developing rapidly, people find hard time to catch the speed of this change. Almost all of the companies are looking for employees that have the twenty-first century skills (McCauley & Wakefield, 2006); creativity, critical thinking, collaboration, communication and problem solving (Boyles, 2012; Gómez-Rey, Barbera & Fernández-Navarro, 2017). Competencies of teachers in this century should be investigated in a broader sense when compared with other occupations because they are educating all the community and they should be role models for every individual. They should be reflecting twenty-first century skills to design creative learning atmospheres, find outstanding solutions to unique situations and be open to live new experiences (Sarybayeva, Berkinbayev, Kurbanbekov, & Berdi, 2018).

3.3. STEM Teacher Competencies

STEM teaching competency is a complicated structure that involves a multitude of factors, not only teacher's content knowledge but also one's attitude toward science, technology and mathematics (So, Ryoo, Park & Choi, 2019). Therefore, there are various classifications of STEM teacher competencies found in literature.

Song (2017) presents three categories for STEM teacher competencies. They are; cognitive characteristics, instructional skills and affective characteristics. The details are given in Table 3.2.

Table 3.2. STEM Teacher Competency Categories (Song, 2017, pp. 65-68)

COGNITIVE CHARACTERISTICS	ability to link between other subjects
	cognition of the concept of integrated STEM
	creativity based on the interdisciplinary knowledge
	flexible thinking beyond the boundary of subject
	knowledge on other STEM subjects
	scientific understanding on the real world and technology
	to recognize problems comprehensively and multilaterally
INSTRUCTIONAL SKILLS	alternative assessment
	instruction using IT
	project based curriculum
	student centered activity
	students' autonomy and responsibility
	teacher as a learning assistant and guide
	to encourage a career connected to science and technology
	utilization of knowledge learned in class
AFFECTIVE CHARACTERISTICS	belief and patience with students' achievement
	communication and cooperation between teachers
	open mind to accept without limitation of individual subject boundary
	self-examination and continuous efforts improving STEM class
	to surmount an anxiety on unfamiliar knowledge of other subjects
	willingness and enthusiasm on integrated STEM

El Nagdi *et. al.*(2018) also determine three major themes characterizing STEM teacher identity; unique nature of STEM teachers' identity, professional characteristics of STEM and personal characteristics of STEM teachers. Additionally, they identify pivotal characteristics of STEM teachers as; collaboration, flexibility, awareness of students' needs, and promoters of equity and involvement.

Srikoom, Faikhamta, and Hanuscin, (2018) especially give detailed explanation of pedagogical content knowledge a STEM teacher possesses; "(a) teachers' knowledge and beliefs about the purposes and goals for teaching and learning STEM, (b) knowledge of STEM curriculum (c) knowledge of students' understanding in STEM (d) knowledge of instructional strategies and representations for teaching STEM (e) knowledge of assessment of STEM learning" (pp.314-315). They conclude their findings with a set of abilities an effective STEM teacher possesses. They are; challenging questions to motivate students, creating authentic STEM learning context, engaging students in a design process, and planning activities to relevant content within STEM and other subjects.

Spillane (2015) determines the important STEM teacher characteristics that the STEM principles look for during teacher hiring process as; having a strong STEM content knowledge, academic, pedagogical and experiential backgrounds, broad experience, willingness to collaborate, open to share knowledge, inclination to engage in project based learning and life-long learner.

Slavit, Nelson and Lesseig (2016) describes the role of a STEM teacher as; curriculum designer, risk taker, learner, collaborator, inquirer, negotiator. They report that STEM teachers apply Poject-Based-Learning (PBL) and focus on students' needs. They are mostly experienced teachers with empathy and commitment to students. Scholars' background and motivation to teach are observed to be the most important factors playing important roles in becoming a good STEM teacher (Kirchhoff and Lawrenz, 2011).

A list of skills and abilities necessary to succeed in next decade has been suggested that includes practical ingenuity, creativity, communication, business and management, leadership, high ethical standards, professionalism, dynamism, agility, resilience, flexibility, lifelong learning, critical thinking, problem solving, collaboration, innovation, digital literacy, initiative, accountability, productivity, responsibility, and self-direction. Educators in STEM disciples must work together. First of all they need to break down the personal barriers and then they need to break down the curricular barriers. Teachers' enthusiasm may go beyond the limits of the course by using scientific or mathematical modelling and engaging with computer programming (Ames, Reeve, Stewardson, & Lott, 2017).

3.4. STEAM Teacher Competencies

Although there is a rapid increase towards STEM/STEAM education, the content of STEAM teacher competencies is not well understood (Honey *et.al.*, 2014; So *et.al.*, 2019). Multi-functional factors affecting teachers' competency in STEAM education can be drawn from previous studies as; appreciating arts, attitude toward science, technology acceptance which determine the creative convergence competency. Positive attitudes toward technology, science and arts, affect the teachers' ability to become a creative and convergent thinker (So *et.al.*, 2019). Kim and Bolger (2017) claim that teachers having creative or big picture thinking ability have greater chance to be successful in STEAM planning and applying. Strong content knowledge, self-confidence and support to implement change make it easy to adapt to new system. Collaboration with colleagues from various disciplines and open-mindedness about integrating different concepts will gradually make it possible to accomplish the desired goals. Choosing effective learning materials and topics suitable for STEAM motivates students in willingness to achieve the determined objectives of the lesson. So *et. al.* (2019) give summary table (Table 3.3) on components of teaching competency and skills in STEM/STEAM education by combining four references. So *et. al.* (2019) also illustrate a structural model for STEAM Teaching Competency contributed by five elements; subject content knowledge, teaching methods and strategies, learning environment/circumstances, evaluating learners and STEAM attitude.

In STEAM education, teachers' professionalism can be assessed by elements including content knowledge, curriculum knowledge, teaching method knowledge, learner knowledge, situation knowledge, and assessment knowledge (Kim & Kim, 2013). Problem-solving through inquires and designing including important elements in connecting with real life. In the domain of curriculum knowledge, understanding of the curriculum of STEAM-related subjects and an ability to reorganize integrate are necessary. Teaching method knowledge can be classified by methods that all knowledge about STEAM-related subjects. That is, it contains teaching methods to build up higher-order thinking and creative problem-solving abilities, class strategies to develop STEAM knowledge and students' intentional participation in class. Learner knowledge and the diagnosis of learners' developmental characteristics and behavioral changes are further

included. In the domain of situational knowledge, creating a learning atmosphere is one of the main elements of teacher professionalism. Finally, in the domain of assessment knowledge, using various assessment methods for various learning experiences is suggested as one of the main professionalism capabilities of STEAM teachers (Kim & Kim, 2013). All these evaluation indicators are summarized in Table 3.4.

Table 3.3. Components of teaching competency and skills in STEM/STEAM education summarized by So *et.al.* (2019, p.49)

Knowledge	Understanding education policy
	Integrative knowledge
	Integrating technology
Skill	Enacting STEM/STEAM lessons
	Establishing cooperative / collaborative learning
	Providing problem-based learning
	Providing inquiry-based learning
	Supporting individualized learning
	Assessment/Reflection
Attitude	Attitude toward STEM/STEAM education
	Recognizing the need for STEM/STEAM education
	STEM/STEAM adaptation and diffusion effort

Therefore, of all teaching competencies required by STEAM education, theoretical competency includes subject and curriculum knowledge, teaching design, class methods, assessments, knowledge about learners, etc. Alternatively, practical competency is categorized into creating learning environments, fostering communication, developing professionalism, creating academic stimulations (interaction, motivation, and inducing students' participation, etc.), forming relations with students (acceptance, respect, and affection, etc.), and developing other general features (a sense of humor, leadership, etc.).

Table 3.4. Kim & Kim's Determined Evaluation Indicators for Teaching Competency for STEAM Education (Kim & Kim, 2016)

Evaluation Area	Evaluation Indicators
Understanding of Subjects	Sufficiently understand the curriculum of STEAM-related subjects
	Analyze and reorganize the related subject curriculum for STEAM classes
	Clearly understand the contents of the related subjects including STEAM classes
	Organize the contents of the related subjects so that they can be naturally connected and integrated
	Properly select important concepts and contents from the other subjects for STEAM classes
Teaching - Learning Methods	Clearly suggest instructional objectives and contents to learn in terms of convergence
	Arouse students' learning motivation by suggesting concrete situations related to their real lives
	Provide students with concrete activities related to learning contents, such as experiences and practice
	Induce defining the problem for oneself
	Properly select and use various teaching methods fit for different class contents and situations
	Instruct based on cooperation with other teachers
	Increase students' understanding by concretely explaining and connecting the class contents with their real lives
	Induce learning procedure through question and feedback
	Clearly understand general class contents, such as class assignments and activity processes
	Induce students to use their STEAM-related knowledge in solving problems
	Induce all the learners to actively participate in assignment performance activities
Inducing Learners to Participate in Learning	Clearly guide learners through the class process to create a self-directed learning atmosphere
	Induce learners to communicate with each other so that they can suggest various opinions
	Construct an open learning atmosphere for creative problem-solving
	Stimulate learning activities so that learners may solve problems initiatively
	Induce performance of assignment through cooperation among learners
	Connect learning contents through suggestion of advanced assignment
Understanding of Learners	Determine the degree of learners' accomplishing assignments and give feedback on a regular basis in class
	Check level of assignment completion frequently
	Diagnose students' learning processes by asking proper questions in class
	Discover students' misconceptions and hard-conceptions of what they have learned and give them feedback in class activities
	Constantly determine students' degree of class participation, such as their interest and attitudes, and give them feedback

Table 3.4. Kim & Kim's Determined Evaluation Indıcators for Teaching Competency for STEAM Education (Kim & Kim, 2016) cont.

Learning Environments and Circumstances	Select and use the most effective teaching medium in the process of STEAM classes
	Develop STEAM class materials and reorganize existing class materials individually
	Arrange learning space and environments properly by considering students' activities included in STEAM classes
	Properly allocate and manage students' various activities time periods in STEAM classes
	Handle unexpected situations in class
	Devise and prepare classes in cooperation with the other teachers teaching other school subjects related to the contents of STEAM classes
Evaluation of Learners	Perform quantitative and qualitative evaluations simultaneously
	Use various evaluation methods to consider the diversity of learners
	Assess students' assignment performance process in connection with their academic results
	Offer immanent and external rewards for continuous learning motivation
	Evaluate higher order thinking ability (creativity, problem-solving ability, etc.)
	Utilize convergent evaluation methods for various subject knowledge
	Provide feedback from evaluation results
Individual Qualification	Believe in and dedicate to STEAM education
	Understand the theory and philosophy in STEAM education
	Form a basic rapport in sufficient communion with students
	Have an attitude which opens students' hearts and accepts the opinions of others
	Have a positive tendency to form cooperation among teachers
	Continuously self-improves though self-diagnosis and reflection

4. METHODOLOGY

There are numerous researches on an ideal, effective, the good or best teacher characteristics but there are only a few papers on STEM or STEAM teacher characteristics. Thus, the purpose of this study was to investigate and list STEAM teacher competencies.

4.1. Research Design

In this study, a phenomenological inquiry method that searched for the essence of the interviewee's own experiences (van Manen, 1990) was used. An open ended questionnaire was prepared to record teachers' true stories. One of the ways of knowing is listening to life stories. The gesture, mimic, tone, and color of the voice of the speaker gives hidden messages about what the person felt during the incident (Seidman, 2013). The interview method in this sense gives various clues on such situations. Seidman (2013) defined telling stories as "a meaning-making process" (p. 7). "Every word people use in telling their stories is a microcosm of their consciousness" (Vygotsky, 1987, pp. 236-237). Interviews are the transformation of experiences into words. The quality of the words selected during the interviews in explaining what has been experienced will reflect that person's emotions and preferences. These were considered as the important issues of the study by the researcher. Open-ended, semi structured, friendly conversations gave freedom to the respondents in showing their true feelings.

This qualitative research included in-depth, semi structured interviews that are formed by using Hierarchical Focusing Method (Tomlinson, 1989) that has five stages;

(i) Determining the domain of items that involves the content analysis established by deep literature review;

(ii) Research focus, the interviewer wished to gather information about a set of competencies was selected from a wide list of related items;

(iii) Questions were written in a hierarchical form. Open to closed ended questions were established as the main frame of the research;

(iv) Interviews were carried out as open-endedly as possible without interrupting or influencing. The speeches were video-taped and audio recorded (Tomlinson, 1989);

(v) The video-taped interviews were analyzed by RITA (Rapid Identification of Themes From Audio Recordings) method (Neal, Neal, VanDyke & Kornbluh, 2015).

4.2. Sample

A purposive sample of five STEAM teachers were attempted to be selected from top twenty STEM high schools determined by the US News (Appendix F). The selection criteria was interviewing with successful STEAM teachers having at least two years of experience on STEAM education. E-mails were sent to one hundred thirty six teachers. Unfortunately, there was no response from most of them. Five of the teachers said they were very busy and apologized about not being able to help. The researcher sent extra e-mails to the teachers who explained how they implemented STEAM in their school on Youtube, but they were also busy and apologized. The researcher sent emails to teachers working at STEAM certified schools, but although an interview with one of the teachers was set, he had to cancel because of an unexpected last minute duty he had to accomplish. Only one of the teachers from STEAM certified schools, who was a math teacher, was able to answer the questions. One of the students of the researcher's advisor helped to get in touch with five STEAM teachers, but only one of them was able to spend her time for an interview. One of the researcher's friends living in US got in contact with her son's STEAM teacher. The also researcher wrote an email to one of the authors of a paper who came out as an expert STEAM teacher and she replied. The fifth STEAM teacher was suggested by the forth STEAM teacher. They have worked collaboratively in STEAM project as team members. The availability of the teachers were asked via email. Five STEAM teachers were interviewed only once because of their workload.

4.3. Instruments

The main data collection tool was a semi structured interview questionnaire. Artifacts to support data from the interviews were the teachers' resumes, and their mind maps on STEAM teacher competencies.

In order to get some idea about the interviewee beforehand, a resume (APPENDIX G) was requested and a short demographic questionnaire (APPENDIX E) was asked to be filled.

In-depth and semi structured interview questions (APPENDIX D) were designed by using Hierarchical Focusing Method (Tomlinson, 1989).

Qualitative data was analyzed with Rapid Identification of Themes From Audio Recordings (RITA) Method.

4.3.1. Triangulation

4.3.1.1. Resumes: Teachers generally mention about their knowledge, skills and abilities in their resumes (APPENDIX G). They share their experiences and certificates. They give information about schools they worked at and education programs they participated in. They include their scholarships and awards. Additionally, some of them list their hobbies and interests. This information also gives important clues about STEAM teacher competencies. In this study, resumes were evaluated for triangulation.

4.3.1.2. Short Demographic Questionnaire: Demographic questionnaires (APPENDIX E) give good background information about certain characteristics of the people, their working environment and their behaviors. This knowledge helped the researcher during the interview process. In this study, teachers' age, gender, teaching experience, skills, hobbies, interests, training programs that they are involved in, technological tools they use, whether they deal with arts or not, their teaching environment, number of students in each class, grade level they teach and duration of STEAM projects were asked. This information was helpful in visualizing the situation the teacher was in while answering the questions.

4.3.2. Rapid Identification of Themes from Audio Recordings (RITA) Method

Qualitative method has many positive influences to researchers. This rich information content offers great perspectives and experiences. Unfortunately, obtaining detailed research results takes a lot of time and effort. However, Rapid Identification of Themes from Audio Recordings (RITA) method eliminates the time consuming defect providing punctual results to the investigators. RITA allows the evaluators to achieve a balance of quickness and satisfaction. RITA can optionally store if topics are described in a positive, negative or neutral frame (Neal et. al., 2015).

The other qualitative analysis techniques involve verbatim transcription, which takes huge amount of time and resources. Omitting verbatim transcription and instead identifying themes from listening to audio recordings is faster and provides more information to the researcher. Additionally, Neal et. al. (2015) claims that the RITA method is as reliable as coding from transcripts. Identification of themes from listening to audio recordings can capture nuance and details in the qualitative data while still producing rapid results.

RITA involves capturing the determined themes in the predefined time segments of an audio recording. It also gives the researcher the opportunity to document nonverbal message hidden in the intonation and disposition which is most probably lost in transcription. RITA is also capable of grading the themes as positive, negative and neutral context.

RITA method compared with other systems is approximately %13 longer than the interview itself and faster than the other methods. It preserves nonverbal characteristic data such as the emphasis and the inclination which is unusual to see in plain texts. Some notes in plain texts may contain nonverbal information but mostly, only data what the interviewer personally chooses to save. RITA method requires neither a special device nor uses any kind of special software. Beyond the conveniences, there are some handicaps to this method. Investigators and the assessors are to determine how to divide the recorded time intervals, which would work as a coding unit. Shorter time intervals may store a detailed data but requires more time to work on it. Longer time intervals may be useful for

coding but the data attained through, is slightly rough. To determine the number of topics for coding in RITA may be a disadvantage, too. More topics to code are less useful for coders but the detailed data attained through it is efficient.

Steps of RITA are given in Figure 4.1 and explained as follows;

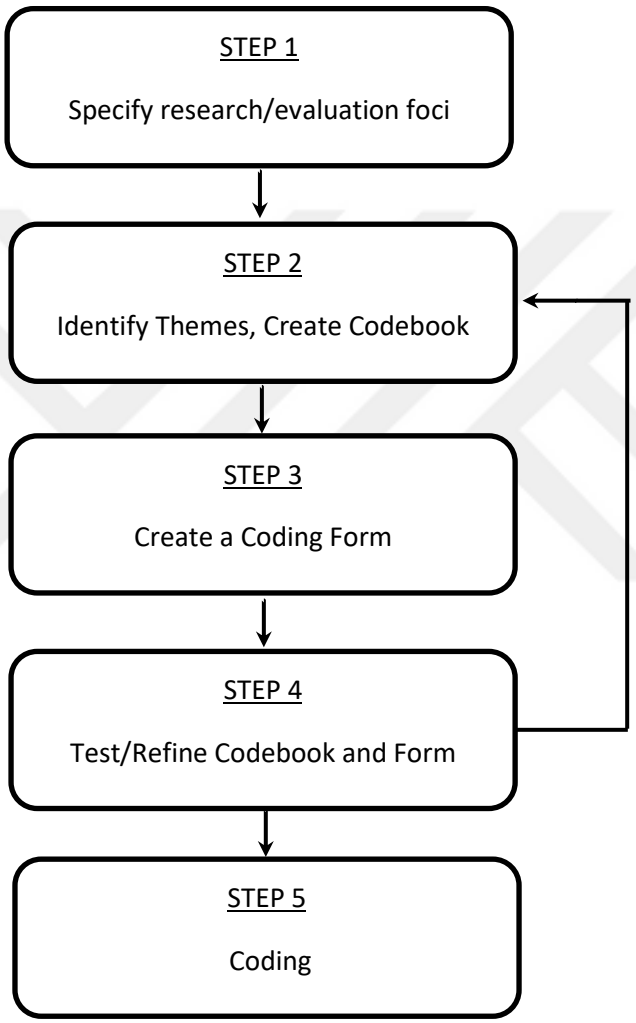


Figure 4.1. Steps of RITA

4.3.2.1. Step 1: Specify Key Research/Evaluation Foci. RITA distinctively groups the main research topics so that it is possible to attain a rapid identification of topics in which is helpful to receive preparative results. The attained analysis should reflect only the essential perspectives of the investigated topic.

In this study, the main foci were as follows:

- Professional Skills
- Attitudes
- Values
- Skills
- Interests
- Health
- Outlook

4.3.2.2. Step 2: Identify Key Themes and Create a Codebook. Coding form including the key topics is designed. Preferably, interview data may be labelled as positive (+), negative (-) or neutral (0).

In this study," InTASC, Model Core Teaching Standards and Learning Progressions for Teachers" (Interstate New Teacher Assessment and Support Consortium, 2013), is used to define key themes for the "Professional Skills" heading. The categories and their descriptions are as follows;

The Learner and Learning

Standards/Progressions #1 & #2: Learner Development and Learning Differences

Standard/Progression #3: Learning Environments

Content Knowledge

Standard/Progression #4: Content Knowledge

Standard/Progression #5: Application of Content

Instructional Practice

Standard/Progression #6: Assessment

Standard/Progression #7: Planning for Instruction

Standard/Progression #8: Instructional Strategies

Professional Responsibility

Standard/Progression #9: Professional Learning and Ethical Practice

Standard/Progression #10: Leadership and Collaboration

Standard #1: Learner Development. The teacher understands how learners grow and develop, recognizing that patterns of learning and development vary individually within and across the cognitive, linguistic, social, emotional and physical areas, and also designs and implements developmentally appropriate and challenging learning experiences.

Standard #2: Learning Differences. The teacher uses an understanding of individual differences and diverse cultures and communities to ensure inclusive learning environments that enable each learner to meet high standards.

Standard #3: Learning Environments. The teacher works with others to create environments that support individual and collaborative learning, and that encourage positive social interaction, active engagement in learning, and self-motivation.

Standard #4: Content Knowledge. The teacher understands the central concepts, tools of inquiry, and structures of the discipline(s) he or she teaches and creates learning experiences that make the discipline accessible and meaningful for learners to assure mastery of the content.

Standard #5: Application of Content. The teacher understands how to connect concepts and use differing perspectives to engage learners in critical thinking, creativity, and collaborative problem solving related to authentic local and global issues.

Standard #6: Assessment. The teacher understands and uses multiple methods of assessment to engage learners in their own growth, to monitor learner progress, and to guide the teacher's and learner's decision making.

Standard #7: Planning for Instruction. The teacher plans instruction that supports every student in meeting rigorous learning goals by drawing upon knowledge of content areas, curriculum, cross-disciplinary skills, and pedagogy, as well as knowledge of learners and the community context.

Standard #8: Instructional Strategies. The teacher understands and uses a variety of instructional strategies to encourage learners to develop a deep understanding of content areas and their connections, and to build skills to apply knowledge in meaningful ways.

Standard #9: Professional Learning and Ethical Practice. The teacher engages in ongoing professional learning and uses evidence to continually evaluate his/her practice, particularly the effects of his/her choices and actions on others (learners, families, other professionals, and the community), and adapts practice to meet the needs of each learner.

Standard #10: Leadership and Collaboration. The teacher seeks appropriate leadership roles and opportunities to take responsibility for student learning, to collaborate with learners, families, colleagues, other school professionals, and community members to ensure learner growth, and to advance the profession (Interstate New Teacher Assessment and Support Consortium, 2013).

4.3.2.3. Step 3: Create a Coding Form. In this step, coding form will be designed that involves the important factors of the research topics. The duration of the intervals may be chosen freely. Short time intervals capture each detail but requires more time and energy. On the other hand, long time intervals are fast and practically evaluated. This data may involve compact and rich information but lacks multi-coding. Some detailed information may be lost in the sake of quick evaluation. A blank template coding form is provided in Appendix H.

4.3.2.4. Step 4: Test and Refine Codebook/Coding Form Based on a Subset of Interviews. Contents and themes in the coding form are to be tested and filtered by evaluating randomly selected interview segments. All researchers code the same selected segments separately and come together to discuss the results, the lacking themes and faults. This helps the researchers to add extra codes in order to optimize and correctly determine the refined length of intervals. Each group topic definitions are determined so that every coder would understand the same thing from each category.

Jaccard index (Bennett & Miller 2010; McGregor *et al.*, 2012) is a name often used for comparing similarity, dissimilarity, and distance of the data set. Measuring the Jaccard

similarity coefficient between two data sets is the result of division between the number of features that are common to all divided by the number of properties.

4.3.2.5. Step 5 – Coding. The research team begins the process of coding all interviews. Knowledge attained through training is necessary in order to be able to define the coding and to work efficiently on the coding time interval procedures. Coders are to determine if the theme is in the given interval: two coders minimum are needed to test the trustworthiness of it. By coding the different comments, through a division such as positive/negative/neutral, it is possible to see the detailed scene clearly in the theme. Through an average of %13 more time is required to code the recorded audio content. The trustworthiness is measured by using the Jaccard coefficient tool.

4.3.2.6.Step 6 - The Codes Analysis. After the completion of a coding, an analysis is put forward for detailed information supply about the structures and features of a theme. Counting positive/negative/neutral comments and figuring out the ratio of positive comments to negative comments may give us useful clues regarding to get a general idea of a theme.

4.4. Procedure

The researcher established a STEAM teacher competencies list with her advisor. Then, good, best, ideal, effective, STEM and STEAM teacher characteristics mentioned in literature were added to the list. Finally, extra characteristics were added during the interviews for STEAM teachers. The mass of data was eliminated where there were synonyms or similar meanings. “InTASC, Model Core Teaching Standards and Learning Progressions for Teachers” is used to define key themes for the “Professional Skills” heading. RITA method was used for the analysis of the interviews.

The interviewer gained a general idea about the selected five STEAM teachers from their resumes and the answers given to the demographic questionnaires before the interviews. (APPENDIX E)

The interviews took place via internet (skype) and they were video and audio recorded. At first, the replicants' opinions were recorded without any interruptions (Hobson, 2002; Lewis, 1992). According to the Hierarchical Focusing Method whenever the answer was not satisfactory or not answered, second level questions were asked in order to get the required information. After the interview, each teacher was asked to draw a mind map for STEAM teacher characteristics. The interviews were evaluated with RITA method.

4.5. Data Analysis

RITA method was used to analyze the interviews. The interview recordings were carefully watched. The gestures and the excited voice implications of the interviewees were recorded. The coding form was filled with the information given by the respondents. Extra competency that is not on the list was added during the evaluation process. All the lists were combined together to establish the STEAM teacher characteristics final list.

Research analysis table was established by going over the interview recordings with the three-minute intervals. The teacher competencies mentioned during this time segments were recorded only once if repeated. After revising the interview speeches, the total number of each characteristic mentioned is calculated by adding the numbers in the same row. The results of the five interviewees were recorded in Figure 5.1. During the investigation, the interviewee's high emotional state, body language and tone of voice stressing the importance of those characteristics was also recorded with a "+" sign. The letter "M" is used to show that the STEAM teacher has included that competency in her/his mind-map. The letter "R" symbolizes the STEAM teachers that mentioned competency in their resume. The STEAM teacher characteristics mentioned while answering the questions without giving a prompt are shown with a "●" sign.

4.6. Trustworthiness and Credibility

In order to ensure trustworthiness in the current study, certain strategies were followed. Internal validity, which is called as credibility in qualitative data refers to the extent of the match between research findings and reality (Merriam & Tisdell, 2016).

Three strategies were followed to shore-up internal validity: triangulation, expert check, and teacher review (Merriam & Tisdell, 2016). At first, the researcher listed the STEM teacher characteristics with her advisor who is a STEAM expert. Since there were few STEM teacher characteristics reported in literature, she finalized the STEM teacher characteristics list (APPENDIX A) from the best, ideal, good and effective teacher lists in literature. (Allgood, 2003; Arnon & Reichel, 2007; Christensen, 1999; Crabtree, 2017; Delso, 1993; Garlick, 1991; Haleck, 1997; Hansen, 1991; Kennedy, 1997; Newman, 1993; Onwugbenu, 2013; Pyne, 2006; Sanchez, 2007; Smith, 2004; Strader, 2009; Thorner, 2017). Then, she prepared an interview questionnaire (APPENDIX B), visited one of the best STEM schools in Istanbul and carried out a pilot study interview with STEM physics, chemistry, biology, and mathematics teachers on best STEM teacher characteristics. The researcher made a revision on the interview questions focusing more on STEM teacher characteristics and using Hierarchical Focusing Method (APPENDIX C).

She interviewed three Turkish STEM teachers who have been active in the field for more than six years and one STEM academic as a second pilot study. After conducting the interviews, she revised the first interview question “What is STEM and what is STEAM?” to “What are the differences between STEM, STEAM and STREAM?” because the respondents were giving book descriptions for the previous question. Another pilot study was accomplished with a STEM academic who is one of the members of the editing board of the Journal of STEM education, from the USA. She was giving short answers but it was noticed that when a question was asked from her life, she preferred to give more information. Meanwhile, the book “Researching lived experience” (van Manen, 1990) pointed out the importance of the same issue in interviews. As a result, the first question was changed to “How did you decide to become a STEAM teacher?”

Seidman (2013) recommends completing the interview three times with up to 3 to 7 days of intervals in between. In the current study, the researcher had to include these sections in one interview question set, because the STEAM teachers were very busy and they could hardly find time for only one interview.

The first part consists of the life story of the teacher. The second part consisted of the details of the targeted experience, which is where further questions were asked to

clarify the situation. The third part dealt with the reflection on the meaning of experience or phenomena. For example, “How does it feel like to be a STEAM teacher?” was asked, which would search for the emotions underneath. These feelings reflect the person’s unconscious selection of important values given to the life experience.

In all of the five interviews, there was a problem with the question, “What are the most important universal values a good STEAM teacher should have?” This was because the teachers were hesitant about the answer. A sociologist suggested using “moral” or “ethical” words instead of “universal”, but although the researcher changed the word, the question was still unclear. The researcher had to explain and in some cases give some examples to enlighten that question. Some of the questions were eliminated because the respondents stated that everybody is supposed to possess these characteristics. The eliminated questions were; “Do you think the personal health (fitness) of a good STEAM teacher is important? Why or why not?” and “Do you think the outlook of a good STEAM teacher is important? Why or why not?”

At the end, a communication specialist who works at the media sector checked the questions and commented that they were knowledgeably prepared measuring the targeted values. He only recommended not to ask questions starting with “What do you think…”. The questions started with this quote changed to “How do you describe...”. He recommended changing “ethical/moral values” to “core values”. The question, “What are the ethical/moral values a STEAM teacher should have?” was changed to “What are the core values a good STEAM teacher should have so that students would take the teacher as a role model?” (APPENDIX D).

5. RESULTS

5.1. Results of the Hierarchical Focusing Method

The STEAM teacher characteristics mentioned while answering the questions without giving a prompt are shown with a "●" sign. These competencies were thought to be prominent, in other words, they were pointed out by the STEAM teachers without giving any reminding words.

The highest mentioned competency without giving any prompt was "Collaborate with Colleagues" which had 7 "●" signs as shown in Figure 5.1.. The second and third highest mentioned competencies were "Hard Working" with 6 "●" signs and "Good Communicator" with 5 "●" signs respectively.

Four out of twenty-one questions were designed according to Hierarchical Focusing Method. The questions and the interpretation of the respondents' answers are as follows;

Question 2: How did your daily life change after you became a STEAM teacher?

The highest change after Scott and Lucy became a STEAM teacher was their heavy work load. They mentioned about working hard on various research topics and spending a lot of time on planning these lessons. As Lucy reminded about collaborating with colleagues to share this heavy duty, Tina was also enjoying the synergy of working together. This work load is shared by collaborating with colleagues that is again mentioned by Scott. Rose made a remarkable quote on holistic approach. She said she started to look at children, education and life as a whole. She said this approach made her see the picture from multiple angles and this made her more empathetic. She is now more flexible and adaptable.

All of the responding teachers mentioned about three (Collaboration with Colleagues, Creator / Innovator, Eager to Learn) out of four most important competencies (labeled as red in Figure 5.1.) and again three (Hard Working, Connecting Concepts,

Appreciate Arts) out of five important competencies (labeled as orange in Figure 5.1.). This result can be a good evidence for the strength of the Hierarchical Focusing Method used in this study (APPENDIX I).

Question 3: What workload do you have in a STEAM project, as a teacher? Would you explain in detail?

When all the teachers evaluated the role of the teacher in a STEAM process, they stressed that working hard is a must. A STEAM teacher is supposed to make good research, collaborate with colleagues to connect concepts and design an effective lesson plan. The answers for this question also contains the most important and important competencies of STEAM teachers as Connecting Concepts, Collaboration with Colleagues, Hard Working, and Researcher (APPENDIX I).

Question 11. What are the important professional skills a best STEAM teacher must have so that the students will gain the 21st century skills?

The answers given to this question also contains the most important (Collaboration with Colleagues, Collaboration with Professionals) and important competencies (Using Technological Tools / Devices, Connecting Concepts, Good Problem Solver). The interesting finding is that the answers given to this question complements the answers given to the previous questions. It was really exciting to find out that Hierarchical Focusing Method was very successful in assigning the most important STEAM teacher competencies determined by the whole study.

Question 14: What are the core values a good STEAM teacher has which she is willing pass to students?

The answers given to this question also complement the answers of the previous questions on completing the important STEAM Teacher Competencies. Passionate for STEAM, Open Minded, Collaboration with Families (involved in Collaboration) were the competencies that were labelled as important.

In this study, twenty two STEAM Teacher Competencies were labelled as most important, important and marked. The aforementioned four questions that were designed according to Hierarchical Focusing Method were able to highlight sixteen of them. The rest of the six competencies that were drawn from the rest of the seventeen interview questions were; Hobbies, Promote Creativity, Managing Behavior, Joyful Lesson, Supporting/Satisfying Needs, and Content Knowledge.

Table 5.1. Demographic Questionnaire Results

	JANE	ROSE	SCOTT	LUCY	TINA
GENDER	F	F	M	F	F
AGE	28	42	54	30	65
PROFESSIONAL TEACHING AREA	Career and Tech. Edu. Arts	Arts	Math	Arts	CREATIVE WRITING
TEACHING YEARS	5	12	29	8	26
STEAM TEACHING YEARS	5	2	8	8	19
TEACHING HOURS PER WEEK	40+	40	25	40	0 - 38
TEACHING CLASS LEVEL	9th grade	K-5th grade	7-8th grade	6-8th grade	3-undergraduate
HOBBIES	Cooking / Baking Gardening	Word-working Gardening Painting Graphic design Promote Creativity Baseball	Soccer Tea	Gardening Kayaking Ceramics Reading	Interior Design Listening Jazz Cooking Gardening Repairing
INTERESTS	Arts Technology Their Integration	Teaching Reaching new & innovative ideas	Spanish Travel	Interior Design My dog Arts	Social Justice Arts Travel Coll. Work Wellbeing Public Education
PLAYING MUSIC INSTRUMENTS	No	No	A little piano	No	Alittle piano Djembe (drum)
PERFORMING ARTS	Working Illustrator	Working Artist Graphic Designer	Origami	Installation Sculpture	Writing Poetry Creative Nonfiction Drawing, Painting Informal Dancing Photography
BOOKS READ	None (at most 1/year)	3-4/month (Audio)	2/year	3	2-3 (Audio)
OTHER TEACHING AREAS	Principles of Manufacturing	STEAM	Coding (Programming) Life Skills	All	Media Studies Philosophy Liberation Studies

Table 5.1. Demographic Questionnaire Results (cont.)

	JANE	ROSE	SCOTT	LUCY	TINA
TECH TOOLS USED	Laptops CAD software, 3D printers, laser cutters,	iPads, Codeapillars, Dash and Dot robots, Lego Wedo Robots, Beebots, and the Lego EV3. Using some	iPads	Chromebooks DSLR cameras construction tools, photoshop elements Free digital apps	Laptop, projector, smartphone, Bluetooth speaker
FROM WHERE STEAM PHILOSOPHY LEARNED	Interested in both art and technology Don't remember when STEAM was first heard	School District Adopted STEM Prog. Searching Internet for STEAM	Attending Math Conferences	instilled in my college educator program collaborating with colleagues	Practical applications came first science education work classroom work stemming from my interests
STEAM TRAINING PROG.	More than 20	different levels of training quarterly trainings robotics training from university professors	Annual Math Conferences	University of Richmond holds a week long teacher institute called Engaging Creative Thinkers	Formally, at least 15 (I became a STEM/STEAM trainer)
STEAM COURSES AT UNI.	I took a lot of art courses, including several that involved technology (ex: web design, digital arts)	Not in a formal setting. Online training courses only	No	No though the concepts we discussed.	No
FREQUENCY OF STEAM APP	Every lesson	Every lesson	3-4 times / Year	Monthly	All workshops
DURATION OF STEAM ACTIVITY	1-2 class period 2-3 weeks 1 semester	3-5 weeks	30 min	Varies greatly	45-120 min.
NO. OF STUDENTS	13-28	25 each (720/week)	15-20	28 (11 classes)	12-35 Online max. 85
TEACHER COLLA. FREQUENCY	At Least Weekly	Often gathered inf.	Once a year	At Least Weekly	Project by project

	Jane	Lucy	Scott	Rose	Tina	TOTAL
PROFESSIONAL SKILLS						
THE LEARNER AND LEARNING						
1. Learner Development						
High Expectations / Willing to be Surprised				1	1	2
Holistic Approach / Whole person		1	1	2 ●	2	6 ●
Promote Student Self Learning				1		1
Focus on student development				3		3
Caring for students				3		3
Motivating/Encouraging			1	1		2
Guiding		1	1	2		4
2. Learner Differences						
Responding in different ways		1	1	4		6
Know Interests			1	2 +		3 +
Recognize Capabilities				5 +		5 +
Supporting/Satisfying Needs		1 R		3	4	8 R
Appreciate Students			2 M	6 +	1	9 + M
3. Learning Environments						
Effective Learning Environment			1	1		2
Creates Continuous Learning Culture						
CONTENT KNOWLEDGE						
4. Content Knowledge						
Content Knowledge	2 R	1	1 +	1	2 + ●	7 ++ R ●
Interested in Various Subjects	M	2			2 ●	4 M ●
Love Teaching Area			1	1	2	4

Figure 5.1. RITA interview analysis results, HFM results, Resume analysis results, Mind-map labels (RITA output results).

	Jane	Lucy	Scott	Rose	Tina	TOTAL
5. Application of Content						
Pedagogical Knowledge		1 + M		1 ●		2 + M ●
General Knowledge		1	1 +			2 +
Connecting Concepts / Integrating Subjects	3 R ●	2	3	2	1 R ●	11 RR ●●
Appreciate Arts	1 R		2 M	2	4 + M R	9 + MM RR
Appreciate Technology			M			M
Appreciate Science			M			M
Appreciate Math			M			M
Student Centered Learning		1		2	1 ●	4 ●
Draw Attention / Engaging / Attracting	M	1	2	3	1	7 M
Make them feel Safe / Do Not Belittle			1	1 ●		2 ●
Patient not Give the Answer			1	M		1 M
Challenges Students				2		2
Joyful Lesson		2	1	4	2	9
Real Life Problems			2	3 ●	1	6 ●
Ask Fruitful Questions		1				1
Access Resources			1	1		2
Passionate for STEAM / Committed	1	M	1	4	1 + M R	7 + MM R
Pedagogical Content Knowledge				1		1
INSTRUCTIONAL PRACTICE						
6. Assessment						
Self-Evaluator		1	1	1	1	4
Assessment/Evaluation	1					1
Effective Feedback / Reflection / Revision	1	1	1	1		4
Responding / Handling Questions			1	1		2

Figure 5.1. RITA interview analysis results, HFM results, Resume analysis results, Mind-map labels (RITA output results). (cont.)

	Jane	Lucy	Scott	Rose	Tina	TOTAL
Promote Student Self-Assessment		1	1	2		4
Promote Peer Assessment	1	2				3
Giving Importance to Efforts			1			1
Observing Students	1 ●	2 +		2M	1	6 + M ●
Openness to Failure / Willingness to Fail		2	2		3M	7 M
Focus on process rather than product	1	1		1		3
Willing to take Student Feedback / Criticism			1	1		2
7. Planning For Instruction						
See the Big Picture				1		1
Visual Thinker				1	1	2
Observing the Environment		2 +	1	3 M ●	2 M	8 + MM ●
Creator / Innovator	1 M	2 + R	2 ●●	5 ++ M	3 R	13 +++ MM RR ●●
Critical Thinker	1	1	1	2	1	6
Diverse Thinker / Outside the Box	1	1		1 M	1	4 M
Risk Taker			2 ●	1 M		3 M ●
Forward Thinking				1		1
Goal Oriented	2			2	1	5
Effective Lesson Planning	1 ●		1	2		4 ●
Prepared (Materials)			1	1	1	3
Student Centered Decisions				1		1
Organized				1	3	4
Researcher	2 ●	2 ●		3	3 ●	10 ●●●
8. Instructional Strategies						
Explaining Clearly				1		1
Uncover Misconceptions		1				1

Figure 5.1. RITA interview analysis results, HFM results, Resume analysis results, Mind-map labels (RITA output results). (cont.)

	Jane	Lucy	Scott	Rose	Tina	TOTAL
Effective Assignment						
Sharing Knowledge						
Various Teaching Methods						
Using Tech Tools /Devices	2 R	3 ●	2 R	2	3 R ●	12 RRR ●●
PROFESSIONAL RESPONSIBILITY						
9. Professional Learning and Ethical Practice						
Learning from Students			M	2		2 M
Eager to Learn / Lifelong Learner	2	2 M	5 M	7 M	5	21 MMM
Ability to Change / Adaptable		1 ●	1	2	1	5 ●
10. Leadership and Collaboration						
Leadership						
Applying Distributed Leadership	1	1				2
Managing Projects	1 M R	1	3	1		6 M R
Managing Time						
Managing Behavior	2	2	3	1	1	9
Good Communicator	1 ●	1 ●	2	2 M ●	1 ●●	7 M ●●●●●
Good Problem Solver	2 M R ●	1	1	5 M ●●	1 R	10 MM RR ●●●
Promote Good Communication		2	1			3
Promote Problem Finding		2				2
Promote Problem Solving		1		1		2
Promote Critical Thinking		1	1	2	1	5
Promote Creativity	1 R	3 R	2 ●	1 +	1 R	8 + RRR ●
Promote Researching/Probing	1 ●	3				4 ●
Reducing Anxiety / Overcoming Struggles				5		5
Punctual						

Figure 5.1. RITA interview analysis results, HFM results, Resume analysis results, Mind-map labels (RITA output results). (cont.)

	Jane	Lucy	Scott	Rose	Tina	TOTAL
Available						
Collaboration						
Building New Relationships	1	1 M		1	1 M	4 MM
Collaboration with Colleagues	5 M R ●●	5 M R ●●	5 ●	2 ●	8 R ●	25 MM RRR ●●●●●●●
Collaboration with Professionals	3 M R ●	4 + M	1	3	4 ++ R	15 +++ MM RR ●
Collaboration with Families	1 M	3 M	2		1	7 MM
Promote Good Collaboration		2	2	2	R	6 R
Open Parent Involvement				1		1
Educating Parents				1		1
ATTITUDES						
Intrapersonal						
Positive / Happy / Smile / Joyful	2			1	1●	4 ●
Enthusiastic	R	1			1	2 R
Sincere			1			1
Hard Working	1 ●	3 ●●●	2 ●	4	3 ●	13 ●●●●●●
Patient			1	M		1 M
Flexible	M	1 M	1 M	1		3 MMM
Curious		3 M ●			4 M ●	7 MM ●●
Humorous			2	M	M	2 MM
Exploring / Improving Self	1		1	4		6
Self Confidence		2 M		3	2	7 M
Perseverance		1 ●				1 ●
Humble						
Empathetic		2		4 M ●		6 M ●
Open-Minded	1 ●			5 M	1 M	7 MM ●
Smart				2	M	2 M
Feeling Successful				1		1

Figure 5.1. RITA interview analysis results, HFM results, Resume analysis results, Mind-map labels (RITA output results). (cont.)

	Jane	Lucy	Scott	Rose	Tina	TOTAL
Well-rounded				3 M		3 M
Live in Moderation			1 ●			1 ●
Interpersonal						
Eager to Teach			1 M	1	1	3 M
Friendly/Rapport	1		2			3
Inspirational	1					1
Initiative						
Trustworthy / Honest	1	1	1	1 M ●		4 M ●
Tolerant						
Good Listener			1●		1 ●	2 ●●
Responsible				1	1 ●	2 ●
Compassionate						
Gentle				1		1
Willingness to be open to new experiences					1 ●	1 ●
VALUES						
Integrity				1 ●		1 ●
Fair	1 ●			1		2 ●
Democratic						
Respectful					1 M ●	1 M ●
SKILLS						
Playing an instrument						
Performing Arts	1 R				1	2 R
Doing Sports						
Having many skills					1	1
INTERESTS						

Figure 5.1. RITA interview analysis results, HFM results, Resume analysis results, Mind-map labels (RITA output results). (cont.)

Hobbies	2	1 + R	1 + R	1 +	1 + R	6 ++++ RRR
Community Projects						
Social Activities						
HEALTH						
Physical Health		1			1	2
Mental Health		1			1	2
OUTLOOK						
Fit						
Looking Smart						
Clean						

M: Mind-Map labels +: Body language and expressions R: Resume Analysis ● Hierarchical Focus Method Analysis

Figure 5.1. RITA interview analysis results, HFM results, Resume analysis results, Mind-map labels (RITA output results). (cont.)

5.2. Results of the RITA Method, Resume Analysis and Mind-Map Labels

Research analysis table (Figure 5.1.) was established by going over the interview recordings with the three-minute intervals. The teacher competencies mentioned during this time segments were recorded only once if repeated. After revising the interview speeches, the total number of each characteristic mentioned is calculated by adding the numbers in the same row. The results of the five interviewees are recorded in Figure 5.1. During the investigation, the interviewees' high emotional state, body language and tone of voice stressing the importance of that characteristic was also recorded with a "+" sign. The letter "M" shows that STEAM teachers included that competency in their STEAM teacher mind-map. The letter "R" symbolizes that STEAM teachers included that competency in their resume. The STEAM teacher characteristics mentioned while answering the questions without giving a prompt are shown with a "●" sign.

For example, Rose expressed her feelings about STEAM education as follows:

> "Then this other opportunity came up and I just kind of lived with it and then it grew. It was like a little seed and it just took over me as a person because I think I was learning also. Because you know, so they say this all the time. Oh. You are gonna be a life-long learner. They like to throw all of these little tag lines at you. Oh whatever. Be quiet, you know. But I really am [stressed] now. And so because I am so learning I feel like I am such an amazing teacher now. I am not just teaching what I learned in college, I am not just teaching what I know, they are teaching meee and I am teaching theeem. And I just love (stressed) it you know, I just love it" (saying the same thing twice with an enthusiastic tone of voice)."

She seemed to be *passionate about STEAM*, so a "+" sign was added to that item.

5.3. Number and Symbol Analysis

The average (ẍ) of the numbers on the Total column is 4.39 and the standard deviation (σ) is 3.97. The values more than three standard deviation (ẍ+3 σ = 4.39 + 3 (3.97) = 16.31) are colored with red. The values between two standard deviations (12.34) and 3 σ (16.31) are colored orange. The values between 1 σ (8.37) and 2 σ (12.34) are colored yellow. The numbers very close to 1 σ (8.37) are colored with pale yellow. This classification shows the importance of the STEAM teacher characteristics from higher (red) to lower (pale yellow). In determining the class of that characteristic, its number is not taken as the only factor but the additional signs, (+), (M), (R) were also counted. For example, "Collaboration with Professionals" item total is 15 +++ MM RR. This total is treated as 15+3+2+2=22 and colored as red. The characteristics that have small total values can be important discoveries in distinguishing the differences between an ideal teacher and a STEAM teacher because as mentioned by all the interviewed teachers, there is slight or no difference between an ideal teacher and a STEAM teacher. This study has its importance on bringing to light the unseen teacher competencies that need to be possessed by STEAM teachers.

The Most Important (labelled as red) STEAM Teacher Competencies are as follows;

- Collaboration with Colleagues
- Collaboration with Professionals
- Eager to Learn / Life-long Learning
- Creator / Innovator

The Important (labelled as orange) STEAM Teacher Competencies are as follows;

- Using Technological Tools and Devices
- Good Problem Solver
- Hard Working
- Appreciate Arts
- Connecting Concepts
- Having Hobbies

The Marked (labelled as yellow) STEAM Teacher Competencies are as follows;

- Promote Creativity
- Passion for STEAM / Committed
- Observing the Environment
- Appreciate Students
- Researcher
- Knowing Content Knowledge
- Curious
- Open Minded
- Collaboration with Families
- Managing Behavior
- Planning Joyful Lesson
- Supporting / Satisfying Needs

The Labelled (as light yellow) STEAM Teacher Competencies are as follows;

- Self Confidence
- Managing Projects
- Observing Students
- Openness to Failure / Willingness to Fail
- Draw Attention / Engaging / Attracting

5.4. Results of Triangulation

At the end of the interview, the respondents were asked to draw a STEAM teacher competency mind map. The competencies they recorded in the mind map is shown with a (M) sign in Figure 5.1.

The STEAM teacher competencies mentioned in each of the teachers' resumes are illustrated with an (R) sign in Figure 5.1.

For example, Jane has the following description in her resume: “Creative and problem-solving-oriented maker, artist, and educator. Enthusiastic about deepening knowledge of engineering and fabrication skills and applying my arts and maker knowledge to new applications.” The following STEAM teacher characteristics were drawn from this description: Creator, problem solver, enthusiastic and content knowledge. Another example may be given from Tina’s resume: “Design and lead interdisciplinary workshops and seminars. Collaborate with subject matter experts across disciplines to create partnerships between academic studies and the arts.” The following STEAM teacher competencies were drawn from this description: connecting concepts, collaboration with professionals.

Some of the cells in Figure 5.1. contain more than one signs implying the importance of that characteristic according to that person. For example; Tina has mentioned “Appreciation for Arts”, 4 times (4 + M R) during the interview. (+) sign shows that in one of these cases, her body language, emotional state and the tone of voice implied the importance of that item. (M) sign shows that “Appreciation for Arts” was one of the characteristics drawn in the mind map. (R) sign is attached to the other signs because Tina has mentioned about taking roles in various projects involving arts in her resume. For example, she was writing poems, integrating music (Jazz) and visual art with engineering education, and writing articles on integrating arts (“Leah Gilliam at Work at Play” and “Math into Visual Art into Math into Poetry,” International Review of African American Art, Vol. 23, Number 3, 2011). These activities interpreted as having appreciation for arts.

Tina was not the only respondent that stressed the importance of appreciation of arts but the other interviewees also mentioned about this characteristic, so this item will be the important findings of this study. It can be said that a good STEAM teacher has appreciation for arts.

Appreciation for arts involves knowing the impact of art activities on the development of student self-awareness, imagination and expression of emotions.

The following STEAM teacher competencies have more than one symbol in the corresponding cells;

- Hobbies; (+ R) four out of five respondents' excitement was recorded with a +ve sign and three out of five respondents included their hobbies in their resume.
- Collaboration with Colleagues
- Collaboration with Professionals
- Good Problem Solver
- Managing Projects
- Creator / Innovator
- Passionate for STEAM / Committed
- Appreciation for Arts
- Pedagogical Knowledge

5.5. Comparison of Ideal Teacher and STEAM Teacher Competencies

In the literature review part, ideal teacher competencies were investigated and a list was established. The codebook was designed by including these competencies, STEM and STEAM teacher competencies mentioned in literature. During the research, the declared characteristics are also added to this list. The comparison output in Figure 5.2 (Kim & Kim, 2016; Slavit, Nelson & Lesseig, 2016; Song, 2017; Spillane, 2015; Srikoom, Faikhamta, & Hanuscin, 2018) shows the differences between the lists highlighting the important distinctions between them.

PROFESSIONAL SKILLS	IDEAL	STEM	STEAM	THIS STUDY
THE LEARNER AND LEARNING				
1. Learner Development				
High Expectations / Willing to be Surprised	√	√		√
Holistic Approach / Whole person			√	√
Promote Student Self Learning	√		√	√
Focus on student development	√			√
Caring for students	√		√	√
Motivating/Encouraging	√	√	√	√
Guiding	√	√		√
2. Learner Differences				
Responding in different ways	√		√	√
Know İnterests	√		√	√
Recognize Capabilities	√		√	√
Supporting/Satisfying Needs	√	√	√	√
Appreciate Students	√	√		√
3. Learning Environments				
Effective Learning Environment	√		√	√
Creates Continuous Learning Culture	√		√	√
CONTENT KNOWLEDGE				
4. Content Knowledge				
Content Knowledge	√	√	√	√
Interested in Various Subjects				√
Love Teaching Area	√			√
5. Application of Content				
Pedagogical Knowledge	√	√	√	√
General Knowledge	√	√	√	√
Connecting Concepts / Integrating Subjects		√	√	√
Appreciate Arts				√
Appreciate Technology	√	√	√	√
Appreciate Science	√	√	√	√
Appreciate Math	√	√	√	√
Student Centered Learning	√	√	√	√
Draw Attention / Engaging / Attracting	√	√	√	√
Make them feel Safe / Do Not Belittle				√
Patient not Giving the Answer				√
Challenges Students	√			√
Joyful Lesson	√		√	√
Ask Fruitful Questions	√		√	√
Access Resources	√			√
Real Life Problems	√	√	√	√

Figure 5.2. Comparison of ideal, STEM, STEAM teacher competencies in literature and the detailed STEAM teacher competencies investigated in this study

PROFESSIONAL SKILLS	IDEAL	STEM	STEAM	THIS STUDY
Passionate for STEAM / Committed			√	√
Pedagogical Content Knowledge	√	√		√
Promote students to apply learned contents in real life			√	
INSTRUCTIONAL PRACTICE				
6. Assessment				
Self-Evaluator	√			√
Assessment/Evaluation	√	√	√	√
Effective Feedback / Reflection / Revision	√		√	√
Responding / Handling Questions	√			√
Promote Student Self-Assessment		√	√	√
Promote Peer Assessment		√		√
Giving Importance to Efforts				√
Observing Students	√			√
Openness to Failure / Willingness to Fail				√
Focus on process rather than product				√
Willing to take Student Feedback / Criticism				√
7. Planning For Instruction				
See the Big Picture	√			
Visual Thinker				√
Observing the Environment				√
Creator / Innovator	√	√	√	√
Critical Thinker	√		√	√
Diverse Thinker / Outside the Box				√
Risk Taker		√		√
Forward Thinker		√	√	√
Goal Oriented	√	√		√
Effective Lesson Planning	√	√	√	√
Prepared (+ Materials)	√	√	√	√
Student Centered Decisions	√	√		√
Organized	√	√	√	√
Researcher	√	√		√
8. Instructional Strategies				
Explaining Clearly	√	√		√
Uncover Misconceptions	√	√	√	√
Effective Assignment	√		√	
Sharing Knowledge	√	√		√
Various Teaching Methods	√	√	√	
Using Tech Tools /Devices	√	√	√	√

Figure 5.2. Comparison of ideal, STEM, STEAM teacher competencies in literature and the detailed STEAM teacher competencies investigated in this study. (cont.)

PROFESSIONAL SKILLS	IDEAL	STEM	STEAM	THIS STUDY
PROFESSIONAL RESPONSIBILITY				
9. Professional Learning and Ethical Practice				
Learning from Students		√		√
Eager to Learn / Lifelong Learner	√	√	√	√
Ability to Change / Adaptable	√	√		√
Encourage career connected to science and technology		√		
Utilization of knowledge learned in class		√		
10. Leadership and Collaboration				
Leadership				
Applying Distributed Leadership		√	√	√
Managing Projects	√	√	√	√
Managing Time	√	√	√	√
Managing Behavior	√	√	√	√
Good Communicator	√	√		√
Good Problem Solver	√	√	√	√
Promote Good Communication	√	√	√	√
Promote Problem Finding	√	√	√	√
Promote Problem Solving	√	√	√	√
Promote Critical Thinking	√	√	√	√
Promote Creativity	√	√	√	√
Promote Researching/Probing	√	√	√	√
Reducing Anxiety / Overcoming Struggles	√	√	√	√
Punctual	√			√
Available	√			√
Collaboration				
Building New Relationships		√	√	√
Collaboration with Colleagues	√	√	√	√
Collaboration with Professionals	√	√	√	√
Collaboration with Families	√	√		√
Promote Good Collaboration	√	√	√	√
Open Parent Involvement	√	√		√
Educating Parents	√			√
ATTITUDES				
Intrapersonal				
Positive / Happy / Smile / Joyful	√	√	√	√
Enthusiastic	√	√		√
Sincere	√			√
Hard Working	√			√
Patient	√	√		√
Flexible	√	√		√

Figure 5.2. Comparison of ideal, STEM, STEAM teacher competencies in literature and the detailed STEAM teacher competencies investigated in this study. (cont.)

PROFESSIONAL SKILLS	IDEAL	STEM	STEAM	THIS STUDY
Curious	√	√	√	√
Humorous	√		√	√
Exploring / Improving Self	√	√	√	√
Self Confidence	√			√
Perseverance	√			√
Humble	√			√
Empathetic	√	√		√
Open-Minded	√	√	√	√
Smart	√			√
Feeling Successful	√		√	√
Well-rounded	√			√
Live in Moderation				√
Interpersonal				
Eager to Teach	√			√
Friendly/Rapport	√		√	√
Inspirational	√			√
Initiative				
Trustworthy / Honest	√			√
Tolerant	√			√
Good Listener	√			√
Responsible	√	√		√
Compassionate	√			√
Gentle	√			√
Willingness to be open to new experiences				√
VALUES				
Integrity	√			√
Fair	√			√
Democratic	√			
Respectful	√		√	√
SKILLS				
Playing an instrument				
Performing Arts				√
Doing Sports				√
Having many skills				√
INTERESTS				
Hobbies				√
Community Projects				
Social Activities	√			√
HEALTH				
Good Physical Health				√
Good Mental Health				√

Figure 5.2. Comparison of ideal, STEM, STEAM teacher competencies in literature and the detailed STEAM teacher competencies investigated in this study. (cont.)

STEM and STEAM teacher competencies were investigated and the characteristics mentioned were marked (√) in the related column. The items that are not marked not necessarily mean that STEM and STEAM education does not involve these characteristics but it means that these competencies were not mentioned in the reviewed papers.

The findings of this study may be given in four groups;

1st Group STEAM Teacher Competency Differences

The characteristics that are not mentioned in ideal, effective, good or best teacher, and STEAM teacher characteristics researches, but are included in STEM teacher characteristics investigations are as follows;

- Promote Peer Assessment
- Risk Taker
- Learning from Students

2nd Group STEAM Teacher Competency Differences

The characteristics that are not mentioned in ideal, effective, good or best teacher, and STEM teacher characteristics researches, but are included in STEAM teacher characteristics investigations are as follows;

- Holistic Approach / Whole Person
- Passionate for STEAM
- Forward Thinker

3rd Group STEAM Teacher Competency Differences

The characteristics that are not mentioned in ideal, effective, good or best teacher characteristics research, but are included in STEM and STEAM teacher characteristics investigations are as follows;

- Promote Student Self-Assessment
- Applying Distributed Leadership
- Using Technological Tools and Devices

4th Group STEAM Teacher Competency Differences

The characteristics that are not mentioned in ideal, effective, good, best, STEM or STEAM teacher characteristics researches. These competencies are the important findings of this study. They are as follows;

- Appreciate Arts
- Openness to Failure / Willingness to Fail
- Interested in Various Subjects
- Having Hobbies
- Make Them Feel Safe / Do Not Belittle
- Patient not to Give the Answer
- Diverse Thinker / Outside the Box
- Giving Importance to Efforts
- Focus on process rather than product
- Willing to take Student Feedback / Criticism
- Visual Thinker
- Observing the Environment
- Building New Relationships
- Live in Moderation
- Willingness to be open to new experiences
- Performing Arts
- Having Many Skills
- Good Physical Health
- Good Mental Health
- Appreciate Technology

The second aim of this research was to investigate whether there were any differences between ideal teacher and STEAM teacher competencies. STEAM teachers seem to work as hard as ideal teachers and at first glance it was really hard to tell the differences between them. Likewise, all the art teachers contributed to this study claimed that there is no or a slight difference between them. The math teacher only mentioned about the biggest difference,

"Connecting Concepts", which is at the core of STEM and STEAM education (Zhbanova, 2017). An ideal teacher does not necessarily integrate various learning areas with each other, but a STEAM teacher's first aim is to combine and harmonize at least two disciplines with each other. Although most of the interviewed teachers thought that ideal and STEAM teacher competencies are alike, it was possible to attain the differences from the responses to the questions that served for the second research question. A summary (Figure 5.3) was established from combining the results given in Figure 5.1. and Figure 5.2. This list involves competencies that are not mentioned for ideal, best, good teacher descriptions in literature, but were acknowledged by the participants.

Connecting concepts, appreciation for arts and having hobbies are the most quoted ones. Observing the environment and passionate for STEAM or Committed to STEAM are the second most mentioned STEAM teacher competencies. Among the list that involves twenty eight competencies, some of them may be unique to STEAM education. An unusual competency among them is "Openness to Failure" or even more interestingly, "Willingness to Fail". How would a good teacher want her/his students to fail? Teachers applying STEM and STEAM activities realize that students investigate deeper when they fail the project in order to find the cause of their failure and how to fix it (Machajewski, 2017). There are also numerous famous people stories on success after failure (Petroski, 2018).

COMPETENCIES	Jane	Lucy	Scott	Rose	Tina	TOTAL
Connecting Concepts / Integrating Subjects	3 R ●	2	3	2	1 R ●	11 RR ●●
Appreciate Arts	1 R		2 M	2	4 + M R	9 + MM RR
Hobbies	2	1 + R	1 + R	1 +	1 + R	6 ++++ RRR
Observing the Environment		2 +	1	3 M ●	2 M	8 + MM ●
Passionate for STEAM / Committed	1	M	1	4	1 + M R	7 + MM R
Openness to Failure / Willingness to Fail		2	2		3M	7 M
Holistic Approach / Whole person		1	1	2 ●	2	6 ●
Building New Relationships	1	1 M		1	1 M	4 MM
Interested in Various Subjects	M	2			2 ●	4 M ●
Diverse Thinker / Outside the Box	1	1		1 M	1	4 M
Promote Student Self-Assessment		1	1	2		4
Risk Taker			2 ●	1 M		3 M ●
Focus on process rather than product	1	1		1		3
Promote Peer Assessment	1	2				3
Performing Arts	1 R				1	2 R
Learning from Students			M	2		2 M
Make them feel Safe / Do Not Belittle			1	1 ●		2 ●
Willing to take Student Feedback / Criticism			1	1		2
Visual Thinker				1	1	2
Applying Distributed Leadership	1	1				2
Physical Health		1			1	2
Mental Health		1			1	2
Patient not Give the Answer			1	M		1 M
Live in Moderation			1 ●			1 ●
Willingness to be open to new experiences					1 ●	1 ●
Having many skills					1	1
Giving Importance to Efforts			1			1
Forward Thinking				1		1
TOTAL : 28 Competencies						

M: Mind-Map labels +: Body language and expressions R: Resume Analysis ● Hierarchical Focus Method Analysis

Figure 5.3. Differences between ideal teacher and STEAM teacher competencies in the order of preference

6. DISCUSSION

6.1. Summary of Research Questions and Interpretations

The purpose of this study was to investigate STEAM teacher competencies using qualitative research that involves interviewing with teachers that have at least two years of STEAM teaching experience. As the research was phenomenological, the lived experiences described were coded as key terms that would include what is said by the respondents. The qualitative data collected enabled the researcher to establish a long list of one hundred and thirty-nine characteristics (see Table 5.1.) which illustrates a wide perspective on STEAM teacher competencies. This was the important goal of the first research question; "How do STEAM teachers conceptualize the STEAM teacher competencies?" The second important exploration was to record how their lived experiences may have shifted or affected participants' perspectives on practices of teaching after becoming a STEAM teacher. The findings were expected to answer the second research question stated as; "How do STEAM teachers define the differences between the ideal teacher competencies and STEAM teacher competencies?" The results were given as a summary (Figure 5.2.) in the previous section. Twelve questions were designed to serve for the first research question and nine questions were designed to serve for the second research question. The inferences, perceptions, ideas and emotions of the repondents were blended with the reflected journals in order to give an unbiased interpretation of the interview recordings (Ortlipp, 2008).

6.2. Research Question 1

The first research question results were given as a figure (Figure 5.1.) in the previous section. The competencies were categorized as mentioned the most (colored as red), mentioned intermediately (colored as orange), mentioned (colored as yellow), mentioned less (colored with pale yellow). In this section, competencies mentioned the most will be discussed in detail.

As the perception of STEAM teacher competencies differ among the interviewed teachers, there are some common, highly mentioned competencies that also have backing evidence in literature. The competency mentioned the most among the investigated one hundred and thirty-nine characteristics is "Collaboration with Colleagues" which is essential for STEAM education (Barbato, 2019). Although Rose says only one or two sentences about collaboration without going into detail, the rest of the teachers explain when and how they have collaborated in detail. Jane is very proud of collaborating with her friends and she says she receives a lot of information from them in an enthusiastic voice showing the pleasure she gets from working together with other teachers to improve the quality of her teaching. Teachers improve themselves faster and easier when they collaborate with experienced teachers who have knowledge on various subjects (Copriady, Zulnaidi & Alimin, 2018; Ismail, Kanesan & Muhammad, 2018). Jane truly trusts them and relies on them about the things that she does not know. They meet at least once every week to discuss how to prepare for the STEAM lesson for the determined subject included in the curriculum. Lucy is also happy about leaning on her colleagues whenever necessary and she says that she has less of a workload compared to non-STEAM teachers. She mentions the importance of collaboration in exchanging and creating ideas and teaching each other about subjects they are familiar with as their experienced appliers. Collaboration increases their knowledge and they start to feel confident in themselves. The more they experience, the more competent at collaboration they become (Ricci & Fingon, 2018). Lucy smiles and giggles, saying that it makes life a little easier, showing the pleasure she feels about collaboration. Sharing experiences and knowledge makes teachers improve in their application of teaching methods which leads the students to succeed (Vincente, 2017). This is one of the reasons why teachers like collaboration. Scott points out the collaboration that occurs at conferences, workshops (Veen, Lam & Taconis, 1998) and on online platforms such as Twitter. He says that these help him get various ideas about different applications of STEAM philosophy in mathematics discipline. Since Tina, as an arts teacher, was interested in many different subjects (such as math, science, history…), she was already collaborating with a lot of people from different disciplines before she started her STEAM journey. She points out the importance of teachers working together as a team in order to experience the lessons themselves before teaching them, and feel stronger together. She has witnessed teachers go through behavioral changes after getting involved in STEAM, such as initiating conversation with teachers they have never

talked before. However, she also points out that it is hard to find time to collaborate since teachers in the US are overloaded with work and underpaid (Connors, 2009; Keefe, 2017; Keefe, 2018; Naylor, 2001).

The second most important STEAM teacher competency determined by the research is “Collaboration with Professionals” which is documented by the American National Science Foundation as, “all students, including the most talented ones, should have the opportunity to experience inquiry-based learning, peer collaboration, open-ended, real-world problem solving, hands-on training and interactions with practicing scientists, engineers and other experts” (National Science Board, 2010, p. 16).

All the interviewed teachers go into good detail regarding collaboration with experts. Rose, Scott, Lucy and Tina have multiple specific instances to recall, while Jane only emphasizes why it is important, rather than giving an example. Since Jane knows about the happiness students feel when they experience a real expert coming to their classroom, she maintains a network of professionals from different fields and tries to invite as many experts as possible, each related to a subject she has to teach during the semester. She plans the lesson in a way that the students do a shrunk down version (Keane & Keane, 2016) of what the expert has brought in as a lived experience of a real world problem solving situation. When students work in teams trying to solve the determined problems, they may want to ask various questions specific to the problem area, and an expert that they can easily reach in the classroom would help them understand the situation better.

Scott, who teaches seventh and eighth graders, says he has parents come to the class to share their experiences, but what parents explain is hardly understood by the students and this makes Scott unhappy. He comments that compared to younger students, high school students can understand and interact with the experts better. Rose complains about the same problem of the professionals’ explanations being above the class level. She once invited a gentleman from NASA and she said that the speech was a bit boring because students wanted to touch and do things instead of just listening. She mentioned an activity called “Genius Hour” where students research a topic they are curious about, and then experts on that field are invited to the school to share their expertise. Although Lucy teaches the same grade of students as Scott, she is happy about collaborating with experts.

She says that she pulls in anyone she can to the classroom to talk to the kids and she is in contact with industry experts all the time. She once met a graphic designer at her second job and he ended up Skyping into the classroom to talk about what he does for a living and how he got into it. She says she enjoys the contribution of professionals and seems to understand its advantages. When experts are included in the STEAM education system, not only do students learn more, STEAM teachers deepen their knowledge about various subjects (National Science Board, 2010). Tina is another teacher that likes to collaborate. She says she feels like there is so much richness involved in people's experiences. Since she loves to learn new things, she collaborates with different people that are experts on various subjects for the purpose of educational projects. She mentions an interesting project aiming to motivate engineering students with jazz music, which was funded by Motorola. A jazz band was invited and answered technical questions about music. Although project goals were not reached, it was helpful for teachers to understand how to integrate different disciplines.

STEAM philosophy builds such an atmosphere that everybody included in this culture becomes a lifelong learner and their passion for learning rises (Kim & Kim, 2016). All participants of the study put great emphasis on how they became a lifelong learner. All of them receive new information from different resources every day. When teachers become more knowledgeable they can design more effective lessons, and students can receive a deep and long lasting understanding of the subjects being covered (Darling-Hammond, 2008). Jane learns from her colleagues and professionals. Scott is active on Twitter, in addition to reading blog posts online and attending conferences. He likes to receive information on a regular basis. He says that he cannot stop learning because knowledge makes him more aware of the world around him. Rose says she was very sad about not having been a lifelong learner before STEAM, because by the time she was a teacher she was constantly hearing these dictating words "you have to be a lifelong learner!" and she says that it was not easy to become one. However, after she became a STEAM teacher, it was not possible for her not to learn anything new every single day. These lines from her interview are noteworthy; "Because I am continuously learning, I feel like I am an amazing teacher now. I am not just teaching what learnt in college. I am not just teaching what I know. They (students) are teaching me and I am teaching them. […] If I have something broken in my house, I take it to school and we learn together". She

started to learn during collaborations with students and colleagues. She also reads short articles and listens to audiobooks. Lucy was doing research and asking experts. She emphasizes the importance of being a role model as a teacher (Izadinia, 2012; Roberts & Dyer, 2004). She said students like to see their teachers learn new things. When the teacher is learning with the kids, the teacher's enthusiasm makes the students enthusiastic about learning. Tina is always curious about various subjects and endlessly wants to learn more. She is trying to keep her pedagogical knowledge fresh and updated. She created a Google search term for STEAM to keep up with the latest activities, taking advantage of technology for learning (Gosper, McNeill, Woo, Phillips, Preston, & Green, 2011). Being a lifelong learner is one of the important competencies for teachers who want to be successful in teaching (Day, 2002).

One of the biggest challenges in STEAM is coming up with unique and engaging project ideas. This requires teachers to be creative (Guyotte, Sochacka, Costantino, Walther & Kellam 2014; Harris & de Bruin, 2018; Peppler & Wohlwend 2018; Simpson Steele, Fulton & Fanning 2016; So, Ryoo, Park & Choi 2019). Students' interests, hobbies, background knowledge, desire to learn new topics and emotions determine the effective STEAM lesson plan and activities (Connor, Karmokar, Whittington & Walker 2014). Jane mentions creative thinking skills, which a STEAM teacher should possess in order to synthesize information from different fields. She says she analyzes her interests trying to find interesting subjects that she wants to learn about, and then designs a creative lesson plan on that subject. She mostly mentions creative problem solving, which is at the core of STEAM education because STEAM teachers face all different kinds of problems in every lesson. There are technological problems, material shortage problems, and most importantly, social and emotional problems that teachers should be able to solve effectively in order to reach the determined learning goals of the activities assigned for that course. Rose supports what Jane has said with the following words; "creativity and problem solving go hand in hand". Rose believes that brain can be trained (Bransford, Haynes, Stein, & Lin, 1998). However, training the brain should start at an early age. As a K-4 teacher, Rose wants children to gain these abilities, and she promotes creativity and problem solving by asking fruitful questions during STEAM lessons (Stylianidou *et al.*, 2018). Since she was used to hearing "No" as an answer when she was a child, she says she almost never says "No" to any idea coming from children and she believes that

STEAM teachers should have this kind of attitude towards their students so the students feel free to use their imagination at the maximum level. Similarly, Lucy mentions the freedom teachers have in STEAM education. She says that she was happy to be able to stretch as far as she wishes to or can imagine. She stresses the importance of creative thinking skills of STEAM teachers. She says she was facing a lot of problems during the application of STEAM projects, because she has had some students who spent time in correctional facilities, who had trouble building healthy relationships with other students. Most of the time, Lucy was in charge of trying to defuse these difficult situations and teaching the students how to solve communication problems among themselves. She says that since she actively performs arts, her creative thinking skills have improved and this has helped her in solving various problems in tough circumstances. Tina also mentions that STEAM allows teachers to feel more relaxed and empowered to be creative. She says she can find more ways to reach more students because everybody is interested in some kind of art. When she plans a lesson that includes different kinds of art performances with which students will express themselves, almost all of the students get involved with the activity. She adds that she applies creative writing in an interdisciplinary way and feels that she is successful with it. For example, she once had a lesson where the students wrote poems about mathematics. To summarize, she lives most of her life in a creative space. Scott says that he likes to use his creativity in designing different lessons on the same subject every year. He says creative lesson ideas arouse curiosity in parents (Henriksen, 2014) and let them interact with their children's school lives on a different level. He states that he feels like he is improving every year, becoming more and more of a STEAM teacher.

6.3. Research Question 2

The second research question results were given as a figure (Figure 5.3.) in the previous section. Twenty eight teacher competency differences between ideal teacher characteristics and STEAM teacher characteristics were recorded. The most important ones determined by the interviewees will be discussed in detail and the ones that need attention will be mentioned. The "Connecting Concepts / Integrating Subjects" item has the highest recognition among the listed characteristics. "Appreciating Arts", "Having Hobbies", "Observing the Environment", "Openness to Failure / Willingness to Fail", "Make them Feel Safe / Do Not Belittle" and "Patient not to Give the Answer" respectively.

It is not easy to integrate various subjects from different disciplines (Milner-Bolotin, 2018). However, it is at the core of STEM / STEAM education philosophy (Grant & Patterson, 2016; Peppler, 2013; Richard & Treichel, 2013) and can be learned (Grant & Patterson, 2016) by attending training programs or from experience. Findings indicate that informal engineering-based projects can provide opportunities for students and teachers to connect with integrated STEM (Burrows, Lockwood, Borowczak, Janak & Barber, 2018). All the interviewed teachers mention having attended numerous training programs on STEM and STEAM education and realizing the strength of interconnectedness (Burrows *et al.*, 2018). Jane points out that the importance of integrating art with different disciplines is higher than most people realize, because it helps people express their ideas in different and unique ways. She gives a striking example about architecture. If engineers and architects designed structures only so that they will not fall over, the results would be much less aesthetically pleasing. Integrated projects would help with the development of soft skills such as communication, too. By getting in contact with people who are experts in different fields, STEAM teachers improve their soft skills like communication and gain new perspectives that enrich their ability to make connections between different disciplines.

Scott says that the math and science topics are naturally connected with each other. Jane supports this opinion, and adds that people find it strange to connect math with dance. Tina also mentions relating math to dance, and again reminds us that each individual is involved in some kind of art activity. She says at least everybody listens to music. She says it is not that hard to connect different disciplines with each other, and is fun to do so. Scott uses origami in his lessons and he says that this really changes the learning atmosphere in a positive way. He is able to talk about volume and surface area with origami which is inherently a form of art. Rose agrees with Jane and Tina in the sense that life cannot exist without art. Consequently, art is a necessity in life because people use arts to express their thoughts and feelings to communicate with each other (Serlin, 2007), and to understand and build relationships with nature (Keane & Keane, 2016). These connections always exist in nature and STEAM education makes it possible to understand the real world better (Braund & Reiss, 2019).

Since teaching is a stressful job (Cooper & Travers 2012; Dunham, 2002; Van Dick & Wagner 2001) and hobbies can help relieve stress (Ferry, 2016), teachers that have hobbies may relax and get ready for the next day easier. Tina says it is healthy to have hobbies. Lucy gives great importance to having hobbies in the same sense. There have been teenagers in Lucy's class who recently got out of correctional facilities, so she has been solving difficult problems every day. Thus, she was under pressure and feeling stressed every lesson. Her hobbies are gardening, kayaking, doing ceramics and reading. She expresses her feelings about having hobbies with the following statement; "A STEAM teacher should absolutely have hobbies. It is very important." She also thinks that STEAM teachers are generally naturally interested in a lot of things. Rose has a great story about hobbies. She said her husband used to insist on her getting a hobby and she continuously turned down his proposal until she became a STEAM teacher. She thought of gaining different skills to become successful in teaching STEAM, and she started wood-working. Afterwards she started gardening and playing baseball. She says her whole life changed thanks to her hobbies. She explains that she used to be much more reserved, timid and shy, but now she is much happier and open to conversation with different kinds of people. Jane also says she needs hobbies to stay sane when she goes home after work. Additionally, hobbies are sources of inspiration where she can draw from for potential project ideas. The first STEAM teacher competency she brings up upon being questioned about them is "having hobbies". Doing arts or having hobbies can also be seen in scientists' personal lives. Root-Bernstein *et al.* (2008) presented that Nobel Prize winners and members of the American National Academy of Sciences and the British Royal Society have had hobbies. Hobbies are also important for successful teaching of science (Braund & Reiss, 2019).

Lucy was lucky to have knowledgeable parents who often took her and her brother out to explore nature. She got used to observe her environment, which aroused her curiosity to learn about various subjects. She says she likes to make connections about how the world works and how things interact. Tina, Rose and Scott all say that after they become a STEAM teacher they started to pay more attention to what happens around them. There is always this question at the back of their minds, asking "Can I use this object or can I use this music in my lesson?" One day Rose brought a broken iron to school and the whole class worked together to learn about the reason it was broken, and how to fix it. Tina came up with an idea to be used in a STEAM lesson while listening to music. One day

Scott was sitting at a café drinking tea and eating donut, and suddenly he had the idea of discovering the surface area of a donut with his students. STEAM teachers constantly observe their environments and try to bring problems from their daily life to class.

Scott and Rose mention two interesting characteristics of STEAM teachers. One of them is “Openness to Failure / Willingness to Fail” and the other “Make them Feel Safe / Not Belittle”. This was an interesting finding because normally every teacher wants their students to succeed. Thibaut, Knipprath, Dehaene & Depaepe (2018) have mentioned four kinds of experiences that can affect a person’s level of self-efficacy. They are; “(a) mastery experiences, (b) vicarious experience, (c) social persuasion, and (d) emotional arousal. If these teaching activities are consistently successful, they tend to raise self-efficacy. On the other hand, if these activities typically end in failure self-efficacy is likely to be lowered” (Thibaut et. al., 2018, p.636). An unusual quote from Machajewski’s (2017; p.5) study says; “Schools should teach students how to fail fast and safely in order to learn and to allow innovation through vulnerability”. To balance these two opposing viewpoints, the interviewees Scott and Rose bring up the second competency that is “Make them Feel Safe / Not Belittle”. They have built a learning atmosphere where failure is an acceptable result, and will not be laughed at or made fun of. Everyone, even the teacher, can fail and it is part of the STEAM mindset.

Danner & Coopersmith (2015) quote Randy Komisar, a seasoned entrepreneur and venture capitalist with Kleiner Perkins Caufield & Byers, saying that nobody wants to fail and it will not be okay to make failure acceptable, but when people fail, they need to learn from it – and that turns the failure into a process that may lead to innovation and resilience.

Some definitions of failure included in Machajewski’s research are;

1. Success is failure to fail
2. Failure is a precondition for success
3. Success is not the opposite of failure
4. Failure is a lost opportunity
5. Failure is an unwelcome outcome that matters. (2017; pp.4-5)

Edmondson (2011) says that wisdom of learning from failure is incontrovertible and can make the person more successful in the long term if she/he knows how to cope with it. If we think about playing games, children can fail at some level but they keep on playing and playing. They improve their skills regarding strategies and move to upper levels fast. This same logic can be applied to STEAM activities as well, Scott and Rose explain.

The last competency that will be discussed is “Patient on not giving the answer” (Karsli & Ayas 2014; Karslı & Ayas 2011). The 5E method included in STEAM education involves student exploration of concepts as the goal of the lesson. It may take time for every student to discover the answer, but teachers have to be patient about not giving out answers to basic questions when students are supposed to find answers by themselves (Sickel & Friedrichsen; 2015).

7. CONCLUSION

The purpose of this study was to illustrate how STEAM teachers conceptualize, define, and actualize what it means to be a STEAM teacher. A phenomenological research method was followed. A literature review, field visit (to one of the best STEM schools in Istanbul) and four pilot studies were completed to design in depth, semi-structured interview questions that served the two research questions; "How do STEAM teachers conceptualize the STEAM teacher competencies?" and "How do STEAM teachers define the differences between the ideal teacher competencies and STEAM teacher competencies?". Five teachers from USA with at least two years of experience as a STEAM teacher were interviewed. Respondents' resumes and STEAM teacher competency mind maps were used for triangulation. Hierarchical Focusing Method was followed to receive interviewees' prominently conceptualized STEAM teacher competencies. Rapid Identification of Themes from Audio Recordings (RITA) method was utilized to capture the facial expressions and tones that reflected the sense of importance of the competency the interviewee was talking about. As a result, one hundred and thirty-nine abilities, characteristics and skills were listed as the STEAM teacher competencies and twenty eight abilities, characteristics and skills were recorded as the differences between ideal and STEAM teacher competencies. "Collaborating with Colleagues", "Collaborating with Professionals", "Life-long Learner", and "Creator and Innovator" were declared the most for STEAM teacher competencies. "Integrating Concepts", "Appreciating Arts" and "Having various Hobbies" were highly mentioned STEAM teacher competencies which ideal teachers might not necessarily possess.

The most critical inferences that can be drawn from the research were as follows; (1) teachers are role models (Lumpkin, 2008), (2) whole individual (social, emotional, physical and mental) improvement is essential for STEAM education (Camara, O'Connor, Mattern & Hanson, 2015; Pelayo III, Mallari & Capili, 2017; Wilson, 2015), (3) teachers and students have the opportunity to discover and express themselves in STEAM education (Hai-Jew, 2011), (4) acquiring various skills (Bybee, 2010) by gaining experience in different areas, for example spending time on hobbies enriches the person's understanding

of the world, (5) Synergy of collaboration gives the participants the energy to explore and learn about the world (Hauth, Cuenca-Carlino, Mills, Allen-Bronaugh & Thompson, 2019), and (6) the 21st century forces everybody to use technology effectively (Bybee & Fuchs, 2006).

The essential skills for a successful living listed by various researchers are; (a) creative thinking, (b) critical thinking, (c) problem solving, (d) collaboration and (e) communication. They are also mentioned as the 21st century skills. STEM and STEAM philosophy is followed to accomplish this goal by presenting children with effective learning environments in order for them to gain these skills. Teachers play a crucial role in reaching these desired outcomes. If they themselves can collaborate effectively, then they can teach others how to collaborate effectively. If they themselves can communicate well with their colleagues, principles, parents and students by building rapport, then they can teach others how to communicate well. In short, teachers can teach what they possess. Therefore, they need to continuously improve to be a good role model for their students. Every individual is unique, every class is unique and every problem is unique. Thus, teachers exploring and improving themselves in numerous fields will have the ability to find creative solutions to various problems. As a result, they will feel self-confident and achieve success more easily.

STEAM education provides many opportunities for teachers to explore and improve themselves. They will be role models for the students they teach in numerous ways such as being a life-long learner, researcher, visual thinker, creator, problem solver, critical thinker, good communicator and collaborator, risk-taker, diverse thinker, motivator, guide, self-evaluator, promoter, observer, innovator, forward thinker, manager, leader, hard worker, inspirational, good listener, fair, tolerant, friendly, initiator, responsible, trustworthy, gentle and so much more. Good STEAM teachers will construct the happy and caring society of the future.

8. LIMITATIONS

This qualitative research was designed to interview with STEAM teachers from best STEAM schools determined by standards and their principles who had role in hiring them, but finding an available STEAM teacher was a highly time consuming process. The search for available STEAM teachers began in March and the last interview was conducted on the 28th of June. During this time there were some STEAM teachers that have accepted the interview but then because of their workload, they had to cancel the meeting. Two of the teachers said that they did not have time for an interview but can give written answers. Because of our research method (Hierarchical Focusing Method), we could not evaluate their answers.

The phenomenological study was conducted with five K-18 teachers. The reliability of this qualitative study was one of the major limitations. Data were collected through in-depth interviews and the research was conducted in a natural setting so it is difficult for this research to be replicated.

The level and the nature of experience with STEAM education varied significantly among the participants. One of the teachers was applying STEAM activities for two years, one of them for five years, two of them for eight years and one of them for nineteen years.

Another limitation of the study was not being able to interview with STEAM teachers from different disciplines. Four of the teachers had an art major and one of them had mathematics major.

9. FURTHER RESEARCH AND IMPLICATIONS

In this study, every STEAM teacher's contribution to investigation of STEAM teacher competencies was valuable. This may lead to the thinking that more interviewed teachers will give more detailed information about the important competencies of STEAM teachers. The principles' perspectives will also enrich the investigation showing different approaches to describe effective STEAM teachers. The same research can be conducted by interviewing more STEAM teachers and their principles.

There are various STEM/STEAM PD programs all around the world and educators are continuously designing new training programs. Therefore, detailed plans should be made to strengthen the competency of teachers which is the prerequisite for success in STEAM education (Kim & Kim, 2016). The research results of this study may be a valuable data for establishing successful STEAM teacher professional development programs. STEAM teacher competencies given in order of importance can give an idea for where to start the teacher training from. The classification of competencies may be taken as modules of the professional development programs.

The list of STEAM teacher competency may be used for teachers' assessment and evaluation. It can also be used for self-evaluation and self-improvement of teachers who would like to develop themselves.

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APPENDIX A: IDEAL TEACHER COMPETENCIES LIST (ESTABLISHED FROM LITERATURE REVIEW)

1. Professional Knowledge
    a. Deep Content Knowledge
    b. Deep Pedagogical Content Knowledge
2. Knowledge
    a. Background Studies Knowledge
3. Professional Skills
    a. Communication
        i. Body Language
        ii. Diction
        iii. Effective Speech / Effective Presenter
        iv. Eye Contact
        v. Facial Expression
    b. Effective Teaching
        i. Preparation Of Lesson Plans
        ii. Preparation Of Lessons
        iii. Draw Attention
        iv. Asks Fruitful Questions
        v. Wide Perspective / Sees The Big Picture
        vi. Gives Helpful And Appropriate Feedback
        vii. Creates Continuous Learning Culture
    c. Application Of Different Learning Approaches, Methods, Techniques
        i. Inquiry Based Learning
        ii. Problem Based Learning
        iii. Project Based Learning
        iv. Constructivist Learning
        v. Discovery (5e) Learning
        vi. Authentic Learning
        vii. Interdisciplinary Learning
        viii. Peer Teaching
        ix. Student Centered Learning

x. Active Learning
xi. Multiple Intelligence
xii. Mind Mapping

d. Good Researcher
    i. Observes And Brings Real Life Problems To Class
e. Good Observer
    i. Corrects Misconceptions
    ii. Recognize The Capabilities Of Every Student / Talent Spotting
f. Problem (Finder) Solver
g. Creative (High Imagination)
h. Critical Thinker
i. Manages The Teaching And Learning Process Well
    i. Good Time Management
    ii. Organizing
    iii. Systematic
j. Assesses And Evaluates

4. Skills
    a. Playing An Instrument
    b. Involving In Arts Activities
    c. Doing Sports
    d. High Manual Skills
    e. Knows Foreign Languages
    f. Effectively Uses Techological Tools
    g. Being Social / Activates Communities Support For Student Success
    h. Other
5. Attitudes
    a. High Emotional Intelligence
    b. Positive And Happy
        i. Never Ending Effort / Enthusiastic / Passionate
    c. Eager To Learn
        i. Current And Recent Improvements In The Area
        ii. Other Disciplines
        iii. Original Applications In Teaching

        iv. Different Learning Approaches, Methods, Techniques
    d. Eager To Teach /Make The Students Learn
    e. Loving, Caring, Welcoming, Warm Hearted, Sensitive
    f. Friendly
    g. Empathetic
        i. Understands Needs
        ii. High Foresight
        iii. Patient
    h. Supportive / Encouraging
        i. Nurture Students' Confidence And Self Esteem
    i. Guiding
        i. Facilitating
        ii. Setting High Goals
        iii. Responsive
    j. Available
    k. Flexible
    l. Humorous
    m. Eager To Collaborate
    n. High EQ
    o. Discovering Self
    p. Behave Same In Class And Outside Of Class
6. Values
    a. Honest
    b. Hard Working
    c. Responsible
        i. Prepared To Class
    d. Democratic / Justice / Fair
    e. Respectful
    f. Helpful / Sharing
    g. Self Belief
    h. High National, Moral And Universal Values

APPENDIX B: STEM TEACHER QUESTIONNAIRE (FIELD TRIP TO ONE OF THE BEST STEM SCHOOLS IN ISTANBUL)

1. STEM'i nasıl tanımlarsınız?
2. STEM etkinliklerinin öğrencilerin üstünde olumlu ve olumsuz etkileri nelerdir?
3. Tüm eğitimin STEM ile yapılmasına olan inancınız nedir?
4. Okulunuzda STEM uygulayan kaç öğretmeniniz var? Branşları neler?
5. Her öğretmen haftada kaç saat derse giriyor? STEM öğretmeni için bu değişiyor mu?
6. İşe alırken öğretmende aradığınız özellikler nelerdir?
7. STEM öğretmeninin bu özelliklere ek olarak sahip olması gereken beceriler var mı?
8. İşe alma süreciniz nasıl?
9. İşe aldığınız her öğretmeni belirli bir eğitim programından geçiriyor musunuz?
10. İşe aldığınız STEM öğretmenine belirli bir eğitim programı uyguluyor musunuz?
11. STEM dersinin sınıfında kaç öğrenci bulunuyor genelde?
12. Etkinlikler için kaç kişilik gruplar oluşturuluyor?
13. Sizce STEM uyguluyorum diyen okulların hangi imkanlara sahip olması gerekir?
14. Öğretmenler hangi sıklıkta STEM etkinliği yapıyorlar.
15. Her STEM ders planının süresi ne kadardır (günlük, haftalık, aylık, 3 aylık)?
16. STEM etkinliklerinin değerlendirilmesi nasıl yapılıyor?
17. Okulunuzda kaç yıldır STEM felsefesi uygulanmaktadır?
18. STEM felsefesi konusunda uzman olduğunuzu düşünüyor musunuz?
19. Özgeçmişinizi bizimle paylaşır mısınız?
20. Öğretmenler STEM eğitimlerini nereden aldılar?
21. Uzman bir STEM hocası ile de görüşebilir miyiz?
22. Veliler STEM uygulaması hakkında görüş bildirdiler mi?
23. STEM ders planı örneği alabilir miyiz?
24. STEM etkinliklerini kitap haline dönüştürdünüz mü?
25. Proje bazlı etkinlik yarışmalarına katılıyor musunuz?
26. Sizce tüm okullar bu sistemi uygulamalı mı?
27. Tüm Türkiye'nin uyguluyor olması için sizce ne yapılması gerekir?
28. STEM uygulanan derslikleri görebilir miyiz?

APPENDIX C: STEAM TEACHER CHARACTERSTICS INTERVIEW QUESTIONS (BEFORE PILOT STUDY)

1. What is STEM?
2. Is there a difference between STEM, STEAM and STREAM? What are they?
3. What are the important characteristics of a STEM teacher
    a. How deep should be a good STEM/STEAM teacher's knowledge of teaching area?
        i. How deep should be a good STEM/STEAM teacher's content knowledge of teaching area?
        ii. How deep should be a good STEM/STEAM teacher's pedagogical content knowledge?
        iii. How deep should be a good STEM/STEAM teacher's general knowledge?
    b. What are the professional skills a good STEM/STEAM teacher has?
        i. How effective must be her/his communication skills?
        ii. How effective must be her/his teaching skills?
        iii. How effective must be her/his observation skills?
        iv. How effective must be her/his searching skills?
        v. Should she/he have problem solving skills?
        vi. Should she/he have high imagination?
        vii. Should she/he be creative? Why?
        viii. Should she/he have critical thinking skills? Why?
        ix. Should she/he have good managing skills of teaching and learning processes?
4. How should be the attitude of a good STEM /STEAM teacher towards students, colleagues, parents and managers?
5. Do you think a good STEM/STEAM teacher should have some hobbies?
    a. Playing an instrument
    b. Painting
    c. Other types of art (drama, dance, poem, story etc.)
6. How should be the attitude of a good STEM /STEAM teacher towards students, colleagues, parents and managers?

7. What are the most important universal values a good STEM/STEAM teacher should have?
8. Do you think the health of a good STEM/STEAM teacher is important?
9. Do you think the outlook of a good STEM/STEAM teacher is important?
10. Are there any differences between the characteristics of a good or effective teacher and a STEM/STEAM teacher? What are they?
11. Do you think every teacher may become a STEM/STEAM teacher? Why?
12. Do you think a specialized room is necessary for STEM/STEAM lessons? If yes, can you describe?
13. What are the possible problems a STEM/STEAM teacher faces during STEM/STEAM process?
14. What are the important indicators of a successful STEM/STEAM application?
15. When you describe difference between traditional teacher and STEM teacher
    a. Happiness of (teachers and students)
    b. Stress
    c. Productivity
    d. Deep Learning
16. Would you describe yourself as a good STEM/STEAM teacher? Why?

APPENDIX D: STEAM TEACHER CHARACTERISTICS FINAL INTERVIEW QUESTIONS (AFTER 4 PILOT STUDIES)

1. How did you decide to become a STEAM teacher?
2. How did your daily life change after you became a STEAM teacher?
    a. Do you try to find problems from real life that would fit the curriculum?
    b. Do you try to talk with the people who have different occupations?
    c. Do you read more articles or journals or books?
3. What workload do you have in a STEAM project, as a teacher? Would you explain in detail?
    a. What are the important details, you should consider before the STEAM activity?
    b. What are the important details, you should consider during the STEAM activity?
    c. What are the important details, you should consider after the STEAM activity?
        i. What are the important points you include in the rubric?
        ii. What type of feedback do you give to the students?
4. What are the possible problems a STEAM teacher may face during STEAM processes?
5. How do you describe a successful STEAM project?
6. Do you think a specialized room is necessary for STEAM lessons? If yes, can you describe?
7. How does the measurement and evaluation process in STEAM philosophy differs from traditional teaching?
8. How do STEAM teachers' instructional practices change after getting training about STEAM education?
9. How do STEAM teachers' personal skills change after getting training about STEAM education?
10. What are the important characteristics of a STEAM teacher?
11. What kinds of knowledge a STEAM teacher have?
    a. How deep is a good STEAM teacher's content knowledge of teaching area?
    b. How deep is a good STEAM teacher's pedagogical content knowledge?

    c. How deep is a good STEAM teacher's general knowledge?

12. What are the important professional skills a best STEAM teacher has so that the students will gain the 21st century skills?
    a. How do you describe communication skills of a STEAM teacher?
    b. How do you describe teaching skills of a STEAM teacher?
    c. How do you describe observing skills of a STEAM teacher?
    d. How do you describe searching skills of a STEAM teacher?
    e. How do you describe problem solving skills of a STEAM teacher?
    f. How do you describe creative thinking skills of a STEAM teacher?
    g. How do you describe critical thinking skills of a STEAM teacher?
    h. How do you describe managing skills of a STEAM teacher?
13. How do STEM and STEAM processes differ? (in terms of)
    a. teacher preparation,
    b. teacher characteristics
    c. application,
    d. time,
    e. materials,
    f. student learning
    g. deep understanding
14. Would you describe the relationship between a best STEAM teacher and her/his students, colleagues, parents, principles?
15. What are the core values a good STEAM teacher is willing to pass students would take the teacher as a role model?
    a. Honesty
    b. Justice
    c. Trust-worthiness
16. Do you think a good STEAM teacher should have some hobbies? Why or why not?
17. Do you think every teacher may become a STEAM teacher? Why or why not?
18. Are there any differences between ideal teacher and STEAM teacher? What are they?
19. Would you describe yourself as a good STEAM teacher? Why?
20. How does it feel like being a STEAM teacher?
21. I want to be a good STEAM teacher what would you recommend me to do?

APPENDIX E: DEMOGRAPHIC QUESTIONNAIRE

NAME:

GENDER: FEMALE [ ] MALE [ ]

AGE:

PROFESSIONAL TEACHING AREA:

TEACHING YEARS:

STEM/STEAM TEACHING YEARS:

TEACHING HOURS PER WEEK:

TEACHING CLASS LEVEL:

1. What are your hobbies?
2. What are your interests?
3. Do you play any instruments?
4. Do you deal with arts (painting, writing poem, writing story, drama, dances, photography, etc.)?
5. How many books do you read every month?
6. What are the other teaching areas you are interested in?
7. What kind of technological tools do you use in your lessons?
8. Where did you learn STEM/STEAM philosophy from?
9. How many STEM/STEAM teacher training programs are you involved in until now?
10. How many hours were each of the programs?
11. Where did you get these training programs from?
12. How many teachers were involved in one training class?
13. Did you have STEM/STEAM courses (undergraduate or graduate levels) at the university?
14. How often do you have STEM/STEAM activities in your lessons per semester?
15. How long do these activities last?
16. How many students are there in your class?
17. How often do you get together with the teachers of other disciplines to work on STEM/STEAM education?

APPENDIX F: BEST HIGH SCHOOLS FOR STEM LIST CRITERIA

U.S. NEWS & WORLD Report's Best High Schools for STEM rankings methodology is based on the key principle that students at these schools must participate in and pass a robust curriculum of college-level math and science courses. STEM stands for science, technology, engineering and math.

To be included in the Best High Schools for STEM rankings, a public high school first had to be very highly ranked in the 2019 U.S. News Best High Schools rankings. That meant that the top 1,000 – a change from the top 500 last year – nationally ranked high schools were eligible for the STEM rankings.

Those eligible schools were next judged nationally on their level of math and science participation and success, using Advanced Placement STEM test data for 2017 graduates as the benchmark to conduct the analysis. The U.S. News Best High Schools for STEM rankings methodology does not rely on any data from the U.S. Department of Education.

AP is a College Board program that offers college-level courses at high schools across the country. College Board defines STEM math as AP courses in calculus AB, calculus BC, computer science principles, computer science A and statistics. It defines STEM science as AP courses in biology, chemistry, environmental science, physics 1, physics 2, physics B, physics C: electricity and magnetism, and physics C: mechanics.

Math and science success at the high school level was assessed by computing a STEM Achievement Index for each school that ranked in the top 1,000 of the 2019 Best High Schools. The index was based on the percentage of all the AP test-takers in a school's 2017 graduating class who took and passed college-level AP STEM math and AP STEM science tests. The higher a high school scored on the STEM Achievement Index, the better it placed in the Best High Schools for STEM rankings.

The maximum STEM Achievement Index value is 100. No public high school evaluated for the 2019 rankings achieved that top score. The highest index was 99.2.

The first step in the rankings process was to compute the STEM Math Achievement Index. It was derived from two variables.

The first was the percentage of AP test-takers in the 2017 graduating class who took at least one AP STEM math course during high school, which was weighted 25%. The second was the percentage of those AP STEM math test-takers who passed at least one AP STEM math test during high school, receiving an exam score of 3 or higher. This variable was weighted 75%.

The next step was to calculate a STEM Science Achievement Index. Much like the math index, it was derived from the percentage of AP test-takers in the 2017 graduating class who took at least one AP STEM science course during high school – weighted 25% – and the percentage of those AP STEM science test-takers who passed at least one AP

STEM science test during high school, receiving an exam score of 3 or higher – weighted 75%.

This means that the methodology weights students taking AP STEM math and science courses at the high school level at 25% and passing those same AP STEM courses at 75%. In other words, passing both AP STEM math and science tests was three times as important in the rankings as simply taking the two AP courses.

The final step in the rankings process was to calculate the overall STEM Achievement Index, a combination of the STEM Math Achievement Index and the STEM Science Achievement Index. Each index was weighted at 50% and then added together to create a composite value that is the STEM Achievement Index score.

The top 250 high schools – unchanged from last year – that achieved a value of greater than or equal to 76.1 in their STEM Achievement Index scored high enough to be numerically ranked. That high index cutoff point was used since it meant that all the top high schools in the STEM rankings had, on average, more than three-quarters of the AP test-takers in their 2017 graduating class take and pass at least one AP STEM math and one AP STEM science test.

APPENDIX G: SAMPLE RESUME

Jane

Objective

Creative and problem-solving-oriented maker, artist, and educator. Enthusiastic about deepening knowledge of engineering and fabrication skills and applying my arts and maker knowledge to new applications.

Experience Principles of Manufacturing Teacher, Energy Institute High School | Houston, TX 2018-present

● Developed new class to teach freshmen students making skills, including design thinking, rapid fabrication processes, CAD skills, and power tool usage

● Helped maintain campus makerspace areas and tools, including laser cutter and 3D printers

● Created and led workshops to train colleagues on makerspace tools

● Collaborated with colleague to develop cross-class projects to include Arduino programming, such as student teams designing, building and programming handheld gaming devices

Maker 2 Market Instructor, TXRX Labs | Houston, TX Spring 2018

● Developed and taught curriculum in collaboration with TXRX and PopShop America to teach high school students maker skills and tools

● Students developed, produced, and marketed a product line, using skills such as laser cutting, screen printing, and 3D printing

Art Teacher, Energy Institute High School | Houston, TX 2014-2018

● Founded art department in a new and growing school

● Led award-winning art car team, C-STEM teams, and National Art Honor Society

● Created engaging project-based learning lessons in line with school's STEM mission

Awards and Honors Energy IHS Teacher of the Year, 2018-2019 school year

● Nominated and voted on by staff

Best Commercial Entry - Houston Art Car Parade, 2017

● Led students and collaborated with other artists to build an art car sponsored by Noble Energy

● Car appeared at Super Bowl Houston, Art Car Parade 2017 and 2018, and Houston Pride 2018

Additional Experience & Skills Jordan Illustrates 2016-Present

● Create original artworks for sale online and in gallery settings

● Maintain online storefront, including SEO, managing inventory, social media presence, and audience analytics

APPENDIX H: CODING FORM

Table H.1. Coding Form

PROFESSIONAL SKILLS	1-3min	3-6min	6-9min	9-12min	12-15mi	15-18min	18-21min
THE LEARNER AND LEARNING							
1. Learner Development							
High Expectations							
Holistic Approach							
Promote Student Self Learning							
Focus on student development							
Caring for students							
Motivating/Encouraging							
Guiding							
2. Learner Differences							
Responding in different ways							
Know İnterests							
Recognize Capabilities							
Supporting/Satisfying Needs							
Appreciate Students							
3. Learning Environments							
Effective Learning Environment							
Continuous Learning Culture							
Freedom of the teacher							
CONTENT KNOWLEDGE							
4. Content Knowledge							

Table H.1. Coding Form (cont.)

	1-3min	3-6min	6-9min	9-12min	12-15mi	15-18min	18-21min
Content Knowledge							
Interested in Various Subjects							
5. Application of Content							
Pedagogical Knowledge							
General Knowledge							
Connecting Concepts							
Appreciation for Arts							
Student Centered Learning							
Draw Attention / Engaging							
Challenges Students							
Joyful Lesson							
Real Life Problems							
Ask Fruitful Questions							
Access Resources							
Passionate for STEAM							
Pedagogical Content Knowledge							
INSTRUCTIONAL PRACTICE							
6. Assessment							
Self-Evaluator							
Assessment/Evaluation							
Effective Feedback							
Responding / Handling Questions							
Promote Student Self-Assessment							
Promote Peer Assessment							
Giving Importance to Efforts							

Table H.1. Coding Form (cont.)

	1-3min	3-6min	6-9min	9-12min	12-15mi	15-18min	18-21min
Observing Students							
Openness to failure							
Focus on process rather than product							
7. Planning For Instruction							
See the Big Picture							
Visual Thinker							
High Imagination							
Observing Environment							
Creator / Innovator							
Critical Thinker							
Diverse Thinker							
Risk Taker							
High Foresight							
Goal Oriented							
Effective Lesson Planning							
Prepared							
Student Centered Decisions							
Organized							
Researcher							
8. Instructional Strategies							
Clarity of Explanations							
Uncover Misconceptions							
Effective Assignment							
Sharing Knowledge							
Various Teaching Methods							

Table H.1. Coding Form (cont.)

	1-3min	3-6min	6-9min	9-12min	12-15mi	15-18min	18-21min
Using Tech Tools /Devices							
PROFESSIONAL RESPONSIBILITY							
9. Professional Learning and Ethical Prac.							
Learning from Students							
Eager to Learn							
Ability to Change							
10. Leadership and Collaboration							
Leadership							
Applying Distributed Leadership							
Managing Projects							
Managing Time							
Managing Behavior							
Good Communicator							
Good Problem Solver							
Promote Good Communication							
Promote Problem Finding							
Promote Problem Solving							
Promote Critical Thinking							
Promote Creativity							
Promote Researching/Probing							
Reducing Anxiety							
Punctual							
Available							

Table H.1. Coding Form (cont.)

	1-3min	3-6min	6-9min	9-12min	12-15mi	15-18min	18-21min
Collaboration							
Building New Relationships							
Collaboration with Colleagues							
Collaboration with Professionals							
Collaboration with Families							
Promote Good Collaboration							
Open Parent Involvement							
Educating Parents							
ATTITUDES							
Intrapersonal							
Positive/Happy/Smile							
Enthusiastic							
Sincere							
Hard Working							
Patient							
Flexible / Adaptable							
Curious							
Humorous							
Exploring / Improving Self							
Self Confidence							
Perseverance							
Humble							
Empathetic							
Open-Minded							
Smart							
Willing to be Surprised							
Interpersonal							

Table H.1. Coding Form (cont.)

	1-3min	3-6min	6-9min	9-12min	12-15mi	15-18min	18-21min
Eager to Teach							
Friendly/Rapport							
Inspirational							
Initiative							
Trustworthy							
Tolerant							
Active Listener							
Responsible							
Compassionate							
Gentle							
Open to Criticism							
Available							
VALUES							
Integrity							
Fairness							
Democratic							
Respectful							
Helpful							
SKILLS							
Playing an instrument							
Performing Arts							
Doing Sports							
INTERESTS							
Hobbies							
Community Projects							

Table H.1. Coding Form (cont.)

	1-3min	3-6min	6-9min	9-12min	12-15mi	15-18min	18-21min
Social Activities							
HEALTH							
Physical Health							
Mental Health							
OUTLOOK							
Fit							
Looking Smart							
Clean							

APPENDIX I: ANSWERS TO THE QUESTIONS PREPARED WITH HIERARCHICAL METHOD

Question 2: How did your daily life change after you became a STEAM teacher?

Table I.1. Answers and Coding for Question 2

Interview Transcript	Coding
I think it is more *difficult to develop a STEAM lesson*, it's more challenging to make up a STEAM lesson that has *artistic sides* to it than it does to just do a math assignment. (Scott)	Hard working Appreciate Art
For myself, I like the fact I always want to push myself to *something new* like what am I going to do next year (Scott)	Creator / Innovator
I've really *enjoyed* these past seven years where I've been able to do this type of, a new type of learning and also *working more closely with my teachers* around me. (Scott)	Passionate for STEAM Collaboration with Colleagues
I started *really observing* differently (Rose)	Observing Environment
If I have something broken in my house, I will take it to school and we will learn together (Rose)	Eager to learn
I got to watch them grow and learn and have their own opinions. Their own way of *solving problems*. (Rose)	Promote problem solving
You guys are arguing. *Why are we arguing***?** I try to focus on the *whole person*. (Rose)	Promoting Collaboration Holistic Approach
But once I applied creative writing in an *interdisciplinary way* in schools, then it is all seemed to work out. People were writing poems about math. (Tina)	Connecting Concepts
I did *collaboration* with a math teacher working on mosaics. (Tina)	Collaboration with Colleagues
I have always just been *interested in so many different things* that it just showed in my lesson plans. (Tina)	Connecting Concepts
I don't feel like my life necessarily changed because of STEM and STEAM because I was already applying that philosophy, but I certainly have been *happier* that it was codified in that way and I had a way of talking about it *with teachers* especially so we knew what we were trying to do. (Tina)	Happy Collaboration with Colleagues
Well you definitely *don't have as much time* to do things for yourself because you're spending time talking about work. (Lucy)	Hard working

Question 3**:** What workload do you have in a STEAM project, as a teacher? Would you explain in detail?

Table I.2. Answers and Coding for Question 3

Interview Transcript	Coding
I think because of doing things that are *cross-curricular*, you know, it's a lot of *coordination with other teachers* (Jane)	Connecting Concepts Collaboration with Colleagues
So it is a lot of *planning* up front but I can't fully compare it to traditional teaching since I've never done that (Jane)	Hard Working
my understanding from my colleagues is that it's a little bit more *intense timewise* (Jane)	Hard Working
STEAM is a tough tough way to go because they have all the *responsibility* and *all this work* without getting the respect that they deserve and the support that they deserve as professionals (Tina)	Hard Working
More *student centered* teachers welcome it (Tina)	Student Centered Learning
Sometimes I am involved in so many *research* on my own (Lucy)	Hard Working Researcher
The workload I can say *super time intensive* (Lucy)	Hard Working
STEAM is *collaborative* so that I find some people to lean on (Lucy)	Collaboration with Colleagues

Question 12. What are the important professional skills a best STEAM teacher must have so that the students will gain the 21st century skills?

Table I.3. Answers and Coding for Question 12

Interview Transcript	Coding
So yeah it's gotta be *super high in terms of being technical users of information*. (Scott)	Using Technological Tools and Devices
I think having *integrated projects* helps with some of those *soft skills* like well also the group projects things like *communication* being able *to seek out information* or like *problem solve* (Jane)	Connecting Concepts Communicator Researcher Problem Solver
be able to *collaborate with other teachers* as necessary or like even *experts in the field* (Jane)	Collaboration with Colleagues Collaboration with Professionals
So those good *communication skills and collaboration* (Jane)	Good Communicator Collaboration
Definitely I feel like I have *to model* certain behaviors like the way I speak to my colleagues. (Rose)	Role Model
I'm always *problem solving* and we're working on problems together.(Rose)	Problem Solver
I think you need to *collaborate* and I think you definitely have to be able to *adapt* (Lucy)	Collaboration Adaptable
I think you need to be able to *communicate with others effectively* (Lucy)	Good Communicator
all I think any teacher needs to have a working *knowledge of technological tools*. (Tina)	Using Tech. Tools / Devices
You know to *do the research* (Tina)	Researcher
You just need to be *current with whatever tools* will make you a *better communicator* as a teacher as an instructor. (Tina)	Using Tech. Tools / Devices Good Communicator
In terms of other skills, *express yourself clearly to your administrators* so that you can get what you need	Good Communicator
all the basic things of being a good teacher being *organized*. (Tina)	Organized

Question 15**:** What are the core values a good STEAM teacher should pass to students?

Table I.4. Answers and Coding for Question 15

Interview Transcript	Coding
I would go back to being a *creative, risk taker* who *never stops learning***.** (Scott)	Creative Risk Taker Life Long Learner
. So we frequently talk about things like what does it mean to be a *good listener* (Scott)	Good Listener
the *dignity of work* and what does it mean to *live in moderation* (Scott)	Passionate for STEAM Live in Moderation
It's a big question. I hope they see me as someone who's like *fair (*Rose)	Fair
Open to new ideas, invested in student success, they should, like working with young people (Jane)	Open Minded
Honesty, Integrity, safety, not only the materials and the environment and the relationship with me is safe. (Rose)	Honest Integrity Make them feel safe
Communication, empathy, teamwork for *sure* (Rose)	Good Communicator Empathetic Collaboration
Perseverance is really important. So is curiosity(Lucy)	Perseverance Curious
I think willingness to *work hard* is something that is not always thought to children (Lucy)	Hard Working
First is respect for each other. *Curiosity. Commitment to listening*. These are the basic ones. *Willingness to be open to new experiences.*	Respectful Curious Appreciate Students Open Minded