DOCTORAL (PHD) DISSERTATION

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THE ADVANTAGE OF *'A'* IN STEAM EDUCATION: EXPLORING SECONDARY TEACHERS' AND STUDENTS' PERSPECTIVES IN HUNGARY AND PALESTINE

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Abstract

This doctoral thesis investigates the implementation and efficacy of STEAM education in secondary schools within the contexts of Hungary and Palestine. This research aims to explore the advantages, challenges, opportunities, and best practices associated with its integration into secondary school curricula in diverse cultural and educational settings. This doctoral thesis employs a qualitative research approach, encompassing activities, observations, a systematic literature review, and interviews to explore the implementation and effectiveness of STEAM education in Hungarian and Palestinian secondary schools. STEAM education nurtures critical thinking, creativity, and problem-solving skills. The research's systematic literature review demonstrates STEAM's goals in education, positive implementation in schools, and outcomes. Subsequent activities such as classroom observations, researcher-led initiatives, and interviews examine and explore the perceptions held by educators and students regarding STEAM education in Hungarian and Palestinian secondary schools. Moreover, the research provides rich qualitative data to reveal the contextual factors influencing STEAM adoption and implementation with theoretical and conceptual frameworks, and practical implications. A comparative analysis approach also displays the commonalities and disparities between Hungarian and Palestinian educational contexts regarding STEAM education. The findings portray a deep understanding of STEAM education and its impact on secondary school students' learning outcomes.

Keywords: *art integration, art-based methods, STEAM education, creativity*

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1. Introduction

1.1 STEAM Education

STEAM is an acronym for Science, Technology, Engineering, Art, and Mathematics and traces back to a pivotal National Science Foundation conference in 2007, which demonstrates the connection between arts, STEM education, and the workforce. STEAM introduces the additional element of 'Arts' and there are many interpretations of this word (Sanders, 2009). The shift, from STEM to STEAM, gained popularity and urged a broader educational approach beyond STEM disciplines (Colucci-Gray et al., 2017). Supporters of STEAM argue that integrating arts into STEM education can enhance cognitive skills and problem-solving abilities which could improve students' academic outcomes (Sanders, 2009). STEAM enhances students' creativity through analysis, critique, and investigation from an artistic perspective (Floerke, 2021). Furthermore, supporters suggest that integrating arts into STEM education can help cultivate 21st-century skills, and enable students to explore interconnections within STEM subjects and between STEM and other areas of life (Ge et al., 2015; Hopia & Fooladi, 2019; Milner-Bolotin & Milner, 2017). STEAM education empowers learners to engage in real-world experiences by combining science, technology, engineering, and mathematics standards with art. STEAM education promotes inquiry-based learning, problem-solving, and practical application. The Institute for Arts Integration and STEAM (2021) point out that STEAM builds upon STEM benefits by offering a more modern and innovative approach, allowing students to link their learning with art practices, design principles, and national standards. This integration aims to provide a culturally enriching learning experience, critical thinking, and innovation among learners. STEAM involves linking two or more disciplines from Science, Engineering, and Math with the arts for mutual teaching and assessment (Institute for Arts Integration and STEAM, 2021). Roehrig et al. (2021) describe STEAM as interdisciplinary

because many disciplines are combining seamlessly to create a cohesive learning environment. STEAM education has been efficient in students' academic grades and life skills and competencies. Students develop new abilities and can express themselves freely and display these new experiences. The switch to STEAM education not only involves adding the arts but about the teaching techniques, the learning, and the framework (Pomeroy, 2012). The idea of STEAM education has become more popular and relevant in today's education, where many researchers and studies have depicted the importance and benefits of integrating STEAM education in curriculums which was first introduced in Indonesia and the United States in 2007 (Perignat & Katz-Buonincontro, 2019; Han & Lee, 2012). STEAM education teaches through activities from all grade levels, from kindergarten to post-doctoral studies. STEAM education promotes positive or negative results for students' learning. Many researchers and educators are pushing forth the integration of arts into STEM education. This is defined as "*the inclusion of liberal arts and humanities in STEM education*" (Spector, 2015, p.5). Jolly (2016) describes how STEM and STEAM are competing against each other, however, they shouldn't be competing they should rely on each other and show the strengths of each subject. The Institute for Arts Integration and STEAM (2021) displays six steps for creating an interdisciplinary STEAM-centered classroom: *"focus, detail, discovery, application, presentation, and link"*. These steps guide students to engage in problem-solving and reflection skills in a collaborative learning environment. When implementing a STEAM-based approach, it's crucial to develop practical lessons associated with standards appropriate for the grade level. For instance, Floerke (2021) displays the integration of mathematics and music where educators can draw similarities by comparing music notes to points on a graph. This approach boosts critical thinking as students analyze the music they listen to and link the melodies in songs to mathematical concepts learned in class. STEAM education's objectives are to prepare children to think critically and creatively, cooperate, innovate, and have proper

communication (Quigley & Herro, 2016). This is an important advantage to education because the world is developing so innovations must be created for the future. The arts create new skills for students from problem and critical thinking, inventiveness, group work, and the ability to have thorough discussions which are vital for students' future (Sousa & Pilecki 2013). The STEAM curriculum concentrates and directs its attention to student-direct learning where teachers and educators provide sufficient guidance and positive and useful criticism (Madden et al., 2013). Therefore, teachers and educators are meant to change the aspect of teacher-centered classrooms to student-centered ones to give them the proper knowledge and readiness for their future after school (Sousa & Pilecki, 2013; Darling-Hammond, 2010; Doniger & Sydow, 2016). The educational system needs to change with time and with this time new methods and techniques should be introduced. Education needs to always be up-to-date and modernized to provide students with triumph and achievement in their lives. Therefore, opening a pathway for STEAM education can ensure the success of students. STEAM education has been efficient not only in their academic grades but also in their life skills and competencies. Students develop new abilities and can express themselves freely and display these new experiences (Díaz & Hernández, 2002).

1.2 STEAM Education in Secondary Schools

If STEAM education is used in high school and higher education, students will perform better and acquire an improved understanding of a certain subject because there is a *"higher level of contextualization of contents"* (Segura, 2017, p. 309-311). Students will make better connections to different subjects together by using STEAM in their classrooms (Guyotte et al., 2014). Furthermore, Dobson and Burke state,

"A balance of critical thinking, analytical skill, and creativity is key for innovation. STEM, arts, and humanities can be integrated to engage students in pursuing a balanced education —an education that

will create more employment opportunities and options in the future" (2013, p. 20, Spyropoulou et al., 2020).

It also allows students to develop their communication skills with one another and raise awareness of the importance of cooperation which is vital to their career post-graduation (Connor et al., 2015; Herro & Quigley, 2016). Through these developmental skills, students will be able to cultivate their confidence and know that mistakes are common and necessary for development and that is what STEAM is trying to encourage (Harris & de Bruin, 2018; Bertrand, 2019). The STEAM curriculum plan currently lacks educator collaboration in unit planning. Ideally, each STEAM unit should involve the combined expertise, resources, and materials of two or more educators. Collaborative planning and teaching by multiple educators enhance content credibility and resource availability. This collaborative approach also ensures accurate alignment with content standards and objectives. There is a persistent need for ongoing research in STEAM education to understand effective teaching practices. It would be valuable for educators to have access to research-backed methods for developing and implementing STEAM curriculum. High school students are now expected to comprehend complex texts, assess source dependability, and create arguments (DeBoer et al., 2010). STEAM education plays a necessary role in preparing students for higher education and future career endeavors. Students need to obtain and develop skills such as communication, writing, expression, critical thinking, and artistic expression; and these skills can be developed through STEAM activities (Gullatt, 2008). STEAM-based activities promote engagement among students and can have impactful learning experiences by developing their inquiry-based problem-solving and working independently or collaboratively. Additionally, through a STEAM-based education, students can feel challenged allowing them to be creative, develop observational skills, and expand the right hemisphere of their brain (Hayman, 2017). However, despite the importance of implementing STEAM in secondary schools, there is a lack of formal training for educators in

using STEAM concepts and this could lead to ineffective integration (Wang et al., 2011). Educators' attitudes, thinking, experiences, and identity efficacy can influence STEAM achievement, therefore, this study becomes fundamental in identifying perspectives on STEAM education at the secondary level (Nadelson, 2013). Shin and Han (2010) also portray how most teachers have positive attitudes about integrating STEAM in the classroom, but many feel they lack practical understanding of how to incorporate it into their teaching. Therefore, professional development is beneficial because it concentrates on building personal and professional confidence, learning new teaching methods, and knowledge about different teaching approaches. Sparks (2002) also supports the advantages of professional development by stating how it provides teachers with a deeper understanding of subject knowledge and pedagogical skills. Guskey (2002) declares when meaningful improvements in education occur it's due to professional development. When conducting effective and practical professional development, educators are given the necessary tools for research, practice, reflection, and an approach to work collaboratively. Despite STEAM's popularity, there is a lack of sufficient accessibility of STEAM education at secondary schools. There is a necessity for more exploration into STEAM goals, initiatives, and perceptions to expand STEAM interest and efficiency. Moreover, there is a lack of literature on the perceptions of STEAM education, its impact on the student, and effective implementation and integration in secondary schools.

Additionally, there is a scarcity of information regarding K-12 STEAM programs and to embrace STEAM programs, administrators and educators require access to effective models that promote departmental collaboration and co-teaching. Beyond research-based methods and models, there's a need for both quantitative and qualitative studies to evaluate the curriculum's effectiveness. For instance, questions need to be answered regarding the academic advantages of

integrating arts into logic-driven content areas, the impact of interdisciplinary curriculum on holistic learning and innovative thinking compared to isolated disciplinary studies, and whether both visual arts and STEM students equally benefit from a STEAM curriculum framework. While the STEAM movement has been steadily expanding, it still requires more data to substantiate its efficacy. Furthermore, firsthand accounts from educators regarding the feasibility of implementation and reflections from students on their perception of interdisciplinary thinking are essential.

1.3 STEAM in Palestine

The Palestinian government has pursued consistent efforts to enhance educational infrastructure, teacher training, curriculum adjustment, and the establishment of a comprehensive education system. The education system in Palestine witnessed significant challenges during the Intifada leading to the closures of schools and universities. Consequently, private initiatives and non-governmental organizations (NGOs) emerged to address the resulting educational crisis and continue to play a vital role in advancing the Palestinian education system today. In Palestine, compulsory education is mandated for children aged 6 to 15 and, after the tenth grade, students undergo an evaluation to determine what section (science section or literary section) is eligible for secondary school. Secondary education concludes when students complete the Tawjihi examination determining admission to higher education institutions. Vocational training opportunities for tenth-grade graduates are limited, with apprenticeships serving as the primary avenue for skill development. Recognizing the significance of practical and theoretical training, the Palestinian government implemented and offered two-year courses for skilled workers or 5 to 8-month courses for semi-skilled workers. There aren’t any specific STEAM organizations or

STEAM integration in schools or curricula in Palestine. However, there is one major non-profit organization that promotes STEM named, Al Nayzak, and their main aim is to

> "Develop, root, and reinforce a new culture that embraces science, and to announce this culture among Palestinian youth so that their competence in productive applied sciences could provide them with better economic opportunities that would lead to their future prosperity."

Their main aim is to develop scientific skills and tools for Palestinians in scientific, entrepreneurship, technology, and engineering capabilities and offer socio-economic chances (Al Nayzak, 2021). The organization targets ages between ten to eighteen years old students and above. The figure below displays the program's aims and journey regarding the development of certain skills.

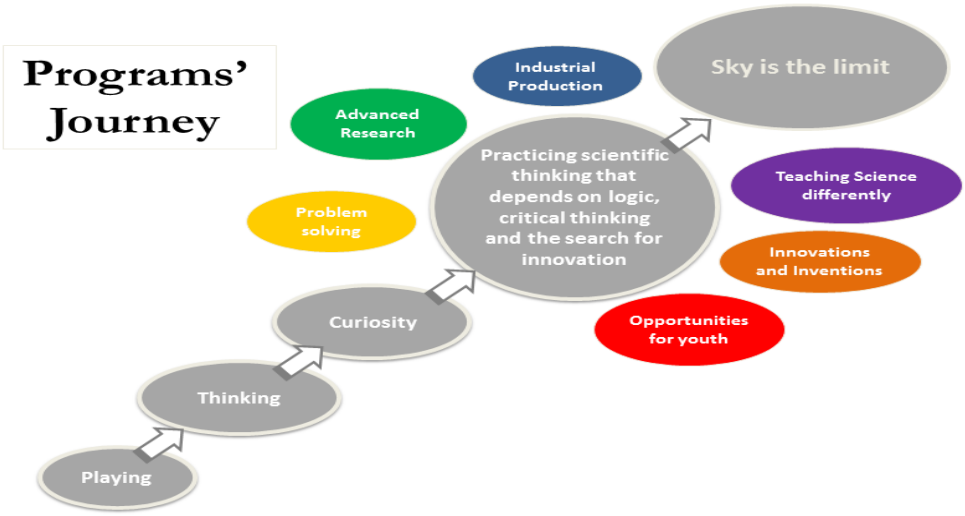


Figure 1: Portrays the programs' journey for STEM education and activities. Source: (Al Nayzak 2021)

The Ministry of Education and UNESCO collaborated, funded by the government of Japan, on a project titled "Enhancing Student Competencies for Innovation and Sustainable Development through STEAM and Coding in Palestinian Educational Institutions" in March 2021. The project involved the training in coding, robotics, artificial intelligence, and 21st-century competencies engaging a STEAM methodology for 100 educators and 1,000 students. Participants were equipped

with laptops and robotics kits and 60 students were incentivized to engage in the national competitions of the World Robotic Olympiad (WRO), and two teams along with their mentors participated in the 2022 WRO International Finals in Germany. The project demonstrated positive outcomes for students to engage in STEAM activities and displayed collaborative achievements (UNESCO, 2023). The Arab American University of Palestine (AAUP) engaged with the Ministry of Education to create the "STEAM Palestine" program in 2019 to integrate Palestinian universities. The program emphasized nurturing students' analytical, problem-solving, and teamwork skills. The program displayed different educational methodologies to foster critical thinking, enhance students' adaptability to contemporary scientific challenges, and develop creativity and positive attitudes toward science, mathematics, and technology among school students. The program was meant to inspire other research initiatives and deepen students' understanding through active participation (AAUP, 2021).

1.4 STEAM in Hungary

Hungary's education system starts with basic education (ISCED I+II) for elementary and then there are three different secondary schools (ISCED III) that are linked to elementary school. Firstly, Secondary Grammar Schools are schools that focus on students' careers in higher education, secondly, Vocational Secondary Grammar Schools are schools that focus on job training and professional education for their students, and lastly, Secondary Technical Schools are schools that concentrate and provide occupational training for their students. Natural science is taught from grades 1-6 (ages 6-12) in four different subjects- biology, geography, physics, and chemistry and carries on from the 7^{th} grade. At the Secondary Technical Schools science is taught in a more complex way from the 9^{th} grade and then from grades 10-12 students can learn one or two subjects from the natural sciences (biology, geography, physics, and chemistry). The students must also

complete a TIMSS and PISA test. However, Hungarian students' results in the math and science section of these tests have been declining between 2000-2012. They are very weak in these subjects and know less than 10-15 years ago (Csapó, 2014). Hungary did change its learning targets and used the targets from Europe 2020, because these learning targets strengthen students' creativity, and their skills and attention to science and math subjects (European Commission, 2010). Hungarians' education policy is shifting to these new objectives that not only strengthen their knowledge and skills but also their personality and growth as an individual. In public education, Hungarian schools focus on complex educational programs in the fields of natural sciences, mathematics, arts, and entrepreneurship. Therefore, the strategy Hungarian schools are aiming for is in support of STEM education. They want to develop a correlation between teachers of natural sciences to teachers working in STEM education. The European Union is the main source of funds assigned to this education strategy to be implemented in schools. As well, other markets and NGOs have been interested in this new education strategy and are assisting the teachers with the proper tools and instruments. Though, the arts have not been mentioned visual culture and music are very much part of the art education in Hungarian schools. Art classes are constrained in some form, but all students until the age of 18 take some form of art during their education, even for their final exam before graduation, students can choose an art subject for instance, fine arts, instrumental music, or folk dance and continue after graduation with art. Also, students who are very interested in the arts in school can take extra classes to improve their skills and can choose different forms of art at the age of 14. Teachers are educated and qualified to teach two different topics from natural sciences to art for example some teachers have a degree in two subjects- Geography and arts. This is an excellent way for teachers to implement the arts in STEM education (Szabo et al;., nd). STEAM education has been implemented in some schools around Hungary- for instance- the Hungarian Eco-School network was initiated in 2000 and has used 40 pilot schools to portray the

success of this plan. It is still being used and in 2006 The Green Kindergarten was introduced and is still present where now more than 2000 members, pre-primary, primary, secondary, and vocational schools are participating (Réti et al, 2015). The main standards and principles for this system reinforce STEM education where transdisciplinary activities are arranged, connecting real-life artists to the school, and meetings and team-building activities can all be seen in this school. Teachers do attend STEAM-related training and workshops to further develop their skills and techniques in their classrooms. Hungary does want to support its talented students where the National Talent Program was created in 2008 to depict the recognition, assistance, and growth of Hungarian talent. The Hungarian Parliament has been giving these opportunities to these students since 2008 and will continue until 2028 to keep supporting them (Szabo et al, 2018).

Another institution that links visual arts with science is the Digital Craft Lab. The Digital Craft Lab is meant to develop and research how arts and science should be connected and has three varieties of activities. Firstly, its members create new technology and materials, create innovative experiments, and then build these new technologies to create experience-based learning programs for schools. STEM is certainly transformed into STEAM and Digital Craft Lab's logo is "Be STEAM",

> "Our main target of this programme is to develop a methodology that can generate the fusion of knowledge sharing, can transfer modern educational contents, and can integrate them into public education. It should be inquiry-based, so can contribute to the complex and procedural knowledge building".

The institution further develops creative problem-solving and ICT results, many exercises are created for the development of their participants. They promote collaboration, interaction, drawing skills, and knowledge about digital-creating technologies. They are trying to implement their program into elementary schools specifically in subjects of mathematics and sciences. With the application of the program into classrooms, students can generate and create visual works using

new techniques which illustrates a positive reaction not only from students but teachers. However, with all positive ventures, some negative aspects will turn up, for instance, teachers found time management, planning, and resources (materials and kits) to be an issue in completing these activities (Szabo et al, 2018).

1.5 Hungary and Palestine in the Focus of STEAM Education

The decision to focus on Hungary and Palestine as research sites for the collection of data in my Ph.D. thesis is rooted in a deliberate and comprehensive consideration of various factors, including their socio-political contexts, educational systems, and the potential for enriching the scholarly discourse in my field of study. Hungary stands as a compelling research site due to its unique position within the European Union and its rich history of educational reforms and policy developments. As a Central European country, Hungary offers a nuanced perspective on educational practices and policies within the broader European context. Its recent educational reforms, such as the introduction of the National Core Curriculum and efforts to enhance teacher training programs, present an opportune moment for in-depth examination and analysis. Furthermore, Hungary's diverse educational landscape, encompassing both public and private institutions, demonstrates the exploration of the complexities of educational governance, curriculum implementation, and student outcomes. Conversely, the choice of Palestine as a research site stems from its distinctive socio-political context and the profound impact of conflict on its educational system. Palestine's educational landscape reflects the intersection of historical, cultural, and geopolitical influences. The ongoing challenges faced by Palestinian students and educators, including restrictions on movement, resource constraints, and the politicization of education, underscore the urgency and relevance of scholarly inquiry into the dynamics of educational development. Moreover, Palestine's commitment to educational advancement,

evidenced by initiatives to strengthen curriculum development and diverse teaching methodologies, presents an opportunity to examine the efficacy of educational interventions in promoting sustainable development. Furthermore, my interest in exploring different perspectives from secondary teachers and students regarding STEAM education played a significant role in selecting Hungary and Palestine as research sites. I aim to provide a holistic understanding of the challenges, opportunities, and perceptions surrounding STEAM education in diverse socio-cultural contexts. Through rigorous data collection and analysis, I seek to uncover insights from the participants regarding STEAM and ultimately, my research endeavors to advance scholarly knowledge.

1.6 Problem Statement

This research investigates Hungarian and Palestinian teachers' and students' perceptions of STEAM education by exploring its effectiveness and examining the support for STEAM. Studies have found that integrating a STEAM-based curriculum can be impactful by understanding complex concepts and making real-world connections through this inquiry-based approach (Gross & Gross, 2016). Education needs always to be updated and modernized to provide students with triumph and achievement in their lives and this could be achieved with STEAM implementation (Díaz & Hernández, 2002). Despite the growing interest and popularity of STEAM education, there is limited knowledge about effective instructional practices, the challenges associated with STEAM instruction, and how to integrate STEAM appropriately. Most schools have not adopted a STEAM curriculum due to district policies and an absence of professional development. Nevertheless, research and literature strongly support STEAM and its effectiveness for the learner (Huser, 2020). Since STEAM education is relatively new and not fully comprehensive, this research aimed to gain a comprehensive understanding of teachers’ and students’ perceptions of

STEAM education. The information acquired could offer valuable insights into opinions regarding the value of STEAM education within secondary schools.

1.7 Significance of the Research

This research delves into the perceptions of teachers and students regarding STEAM education focusing on its implementation, importance, and support for student development. It proposes to improve scholarly research by investigating attitudes toward STEAM education. The implementation of a STEAM model promotes interdisciplinary learning by engaging both logical and creative aspects of the brain (Anisimova et al., 2019). The research emphasizes the importance of understanding how to support and promote STEAM education in secondary schools. It poses questions for educators and administrators on the necessary resources for effective STEAM learning to prepare secondary school students with essential skills for their education and future careers. Another goal is to also share the positive case studies and research on integrating and utilizing STEAM in the classroom. Lastly, the research will utilize a qualitative approach to investigate teachers' and students' perceptions of STEAM education. The research questions, literature review, and theoretical framework steered the research to uncover insights into how educators and students perceive STEAM education, its implementation, importance, and challenges. Findings from this research can guide educators in accurately describing and implementing STEAM, supporting the development of STEAM initiatives, and promoting student interest in STEAM lessons. There is limited research in Hungary and especially Palestine on teachers' and students' insights on STEAM education at the secondary level and this research aims to display their perspectives and perceptions regarding the importance of STEAM education. As mentioned, the research utilized a qualitative approach to collect and analyze data, beginning with STEAM activities and observations with students and interviews with teachers and students

conducted by the researcher. The outcomes of this study can positively influence perspectives on STEAM education by motivating teachers to adopt new teaching methods and practices, as well as, providing school administrators with a deeper understanding of the significance of STEAM education for secondary students. The study participants included educators and students from secondary levels from two schools in Hungary and three schools in Palestine.

1.8 Research Questions

These research questions were tackled and expectantly answered throughout the research about STEAM education. What are the benefits of arts in education? How do the arts promote stronger cognitive functions in individuals? What are the challenges of implementing STEAM in the curriculum in Palestine and Hungary? What are the perceptions of teachers, administrators, and students towards STEAM education? How do teachers and administrators view the implementation of STEAM education in their schools? What are the differences between teachers' and students' perceptions of STEAM education? How can schools implement and integrate STEAM education? Additionally, qualitative research questions were posed during interviews to gain deeper insights into teachers' and students' perceptions and practices related to STEAM education.

2. Theoretical and Conceptual Framework

2.1 Introduction

In the ever-evolving landscape of education, the integration of STEAM has emerged as a foundation for adopting innovative thinking, problem-solving skills, and collaboration among learners. The theoretical frameworks provided by Jean Piaget and Lev Vygotsky offer valuable insights into the cognitive and socio-cultural dimensions of learning and development. This research attempts to formulate a theoretical and conceptual framework for STEAM education by combining the pivotal contributions of Piaget, Vygotsky, Dweck, Ryan and Deci, Fullan, and the Conceptual Model of the P21 Framework for 21st Century Learning by illustrating pathways for effective pedagogical practices and curriculum design. The thesis aims to address and integrate these perspectives within the context of STEAM education.

-How can Piaget's constructivist principles inform the design of STEAM learning experiences that promote active engagement and conceptual understanding?

-What are the ways Vygotsky's socio-cultural framework be applied to cultivate collaborative learning communities and foster socio-cognitive development in STEAM disciplines?

By addressing these inquiries, this research endeavors to clarify the theoretical foundations by supporting effective STEAM education practices, thereby empowering educators to cultivate a new generation of innovative thinkers, problem-solvers, and collaborators to navigate the complexities of the 21st-century global landscape. The thesis seeks to bridge the gap between theory and practice by displaying the effectiveness of STEAM implementation in learning environments that inspire creativity, resilience, and lifelong learning among students.

2.2 Constructivist Theory

"The principal goal of education is to create individuals who are capable of doing new things, not simply repeating what previous generations have done" - (Piaget, 1973).

Jean Piaget's constructivist theory proposes that learners actively construct their understanding of the world through interactions with their environment. The main themes of Piaget's framework are the concepts of "*assimilation, accommodation, and equilibration"*, these concepts explain how individuals merge new information with existing cognitive structures, thus enabling intellectual growth. Combining Piaget's constructivist perspective in STEAM education, educators can design new learning experiences that challenge students to explore, experiment, and engage in hands-on activities, therefore, developing a deep understanding of disciplinary concepts and promoting metacognitive awareness. When students engage in creative, hands-on art activities, they are passively receiving information, but actively creating, experimenting, and connecting with the subject matter (Piaget, 1973). This active involvement enhances understanding and contributes to lasting memory retention. STEAM education aligns with Piaget's philosophy by fostering an environment where students can actively engage in creative problem-solving which is a critical skill for students' learning development. Furthermore, the constructivist theory asserts that learners actively construct their understanding through interactions with their environment and that education should focus on creating individuals who are capable of innovative thinking (Piaget, 1973). This perspective aligns with interdisciplinary learning, as it encourages students to connect concepts from diverse subjects, enabling them to build a comprehensive understanding of complex issues.

2.3 Socio-Cultural Theory

"Every function in the child's cultural development appears twice: first on the social level and later on the individual level" –(Vygotsky, 1978)

Lev Vygotsky's socio-cultural theory emphasizes the role of social interactions and cultural items in shaping cognitive development. Vygotsky introduced the concept of the zone of proximal development (ZPD), which describes the tasks that learners can accomplish with the assistance of more educated and experienced learners. Moreover, Vygotsky portrayed the significance of scaffolding where educators provide temporary support to facilitate learners' development toward independence in their learning. Through Vygotsky's framework, STEAM education displays a collaborative learning environment that fosters peer interaction, collective problem-solving, and the 'co-construction' of knowledge. He describes how vital collaboration is and how students can extremely benefit from it where they can describe their life experiences, skills, and different approaches to learning. This idea is not a new concept, but the implementation of it into classrooms is new where it strays away from the traditional way of learning. Students can put forth their narrative context in the class to their classmates and teachers becoming more engaged in the learning and creative experience (Thomas & Chan, 2013; Guyotte, et al. 2015). Furthermore, Vygotsky's sociocultural theory underscores the significance of social interactions and cultural contexts in the development of human intelligence. Interdisciplinary learning mirrors this concept by creating socially enriched learning environments where students collaborate, share ideas and learn from one another's perspectives. It nurtures an atmosphere of shared knowledge construction, which resonates with Vygotsky's belief in the social nature of learning and the importance of cultural context in intellectual development. Lastly, Vygotsky's sociocultural theory underscores the role of social interaction and cultural context in cognitive development where these social

interactions and cooperative learning enhance comprehension and influence long-term knowledge retention.

2.4 Self-Determination Theory

Deci and Ryan (1985) are the founders of the Self-Determination Theory (SDT) and explain how engagement is a product of three psychological needs: *"autonomy, competence, and relatedness"*. This theory asserts that when these needs are met learners are more intrinsically motivated and more engaged in their learning. Autonomy enables students to have a sense of choice and control, competence reflects their feeling of understanding, and relatedness refers to their need for social connections. Recent research has provided large evidence supporting the role of SDT in raising engagement and emphasizing the importance of satisfying these fundamental psychological needs to create an engaging learning environment (Deci & Ryan, 1985). Fredricks et al. (2004) have identified various dimensions of engagement including behavioral, emotional, and cognitive. Behavioral engagement includes active participation in classroom activities, emotional engagement pertains to students' reactions to the learning environment, and cognitive engagement is tied to their mental effort and investment in learning. Lastly, engagement in education is a concept that has evolved and is increasingly recognized as a multi-layered construct that goes beyond mere participation and touches upon intrinsic motivation, psychological needs, and the depth of cognitive involvement.

2.5 Growth Mindset Theory

Carol Dweck's groundbreaking work on the growth mindset theory theorizes that individuals who believe that their abilities can be developed through dedication and hard work are more likely to embrace challenges and persist in the face of setbacks (Dweck, 2006). The arts

associate effortlessly with this theory by encouraging students to view mistakes as opportunities for growth. In the process of creating art, students often encounter obstacles, make revisions, and learn from their errors. These experiences foster a resilient attitude and a willingness to tackle complex tasks. STEAM education caters to this theory by providing a variety of opportunities for students to express their understanding and creativity in different STEAM activities. Students with varying talents, whether in visual arts, performing arts, or creative writing can find a platform for their unique abilities. This diversity in artistic expression reinforces the idea that growth and development can occur in different forms promoting a comprehensive understanding of the growth mindset. Contemporary educational psychology has highlighted the role of self-regulated learning in the development of a growth mindset (Zimmerman, 2000). The arts encourage students to take ownership of their learning by setting goals, reflecting on their progress, and making adjustments as necessary. In the work by Gordon Gyori (2020), shadow education is narrowly defined as fee-based educational activities outside the regular school environment. Following this definition, it delves into theoretical discussions and highlights key research directions where he proposes a fresh perspective to gain an understanding of certain aspects of shadow education and related phenomena through the lens of *"educational behavioral science".* This field combines psychological, sociological, economic, behavioral, and educational viewpoints. Gyori suggests that this multidisciplinary approach can help in comprehending the evolving and increasingly influential role of shadow education in learning and teaching (Gordon, 2020a).

2.6 The Change Theory

Michael Fullan's Change Theory highlights the importance of combining capacity building with accountability for effective educational change. Fullan's model of reform works at the school, community, and district levels by explaining the need for clarity, communication, and policy

support for change. The Change Theory recommends four phases: initiation, implementation, continuation, and outcome which are vital to the success of a STEAM program. Fullan's understandings portray the significance of ongoing support, professional development, and resource allocation to integrate STEAM successfully into the education system.

2.7 The Framework for 21st Century Learning

The Framework for 21st Century Learning addresses the evolving demands of a globalized world and shows some key components: Key Subjects, Learning and Innovation Skills, Information, Media and Technology Skills, and Life and Career Skills. The framework emphasizes interdisciplinary themes within key subjects promoting critical thinking, creativity, and collaboration. As the world is rapidly changing, these skills are crucial for students' success, by pushing adaptability, problem-solving, and effective communication. The Framework for 21st Century Learning offers a comprehensive approach to preparing students for the challenges of the modern workforce and aligns with the objectives of STEAM education. Therefore, both the Change Theory and the Framework for 21st Century Learning demonstrate the use and importance of implementing STEAM education. The principles obtained from these frameworks inform the study's exploration of teachers' and administrators' perspectives on STEAM, supporting the development of innovative, problem-solving, and collaborative skills among students.

Figure 2 portrays the Conceptual Model of the P21 Framework for 21st Century Learning, illustrating 21st Century Student Outcomes and Support Systems (Partnership for 21st Century Skills, 2013). According to Remake Learning (2016), the learning environment enables teachers and administrators to use a STEAM-based approach to create meaningful learning experiences. Professional development is essential to integrate these skills and uphold the initiative. The main subjects and 21st Century themes encompass English (reading or language arts), World Languages,

the Arts (music or visual art), mathematics, economics, science, geography, history, government, and civics (Partnership for 21st Century Skills, 2013). Life and career skills encompass flexibility and adaptability, social and cross-cultural skills, leadership and responsibility, and productivity and accountability. In the Learning and Innovation Skills domain, students are encouraged to collaborate effectively, think creatively, innovate in their work, and communicate ideas clearly (Miller et al, 2023). Integrating the Information, Media, and Technology Skills domain in a STEAM-based approach helps students develop information, communications, and technology literacy, enabling them to use information accurately and creatively for their projects or issues.

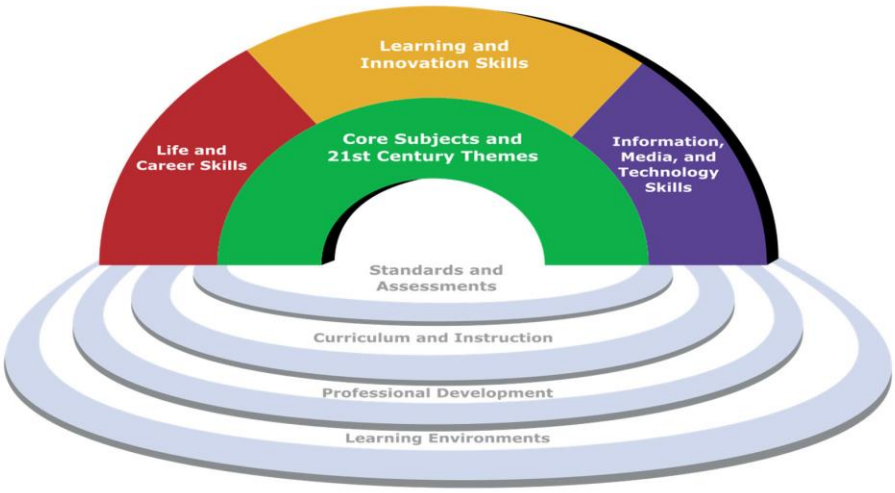


Figure 2: P21 Conceptual Framework for 21st Century Learning. Source: (Partnership for 21st Century Skills, 2013)

2.8 Conclusion

In conclusion, the theoretical and conceptual framework chapter of this Ph.D. thesis has served as a foundational keystone, providing a comprehensive combination of theoretical perspectives and conceptual frameworks that reinforce the study's overarching research objectives. This chapter has explained the theoretical foundations that inform the study's approach, methodology, and interpretation of findings. The research drew upon diverse theoretical

approaches and conceptual frameworks that sought to construct a holistic understanding of the complexities essential within the study. Furthermore, the theoretical and conceptual framework chapter has underscored the significance of interdisciplinary perspectives and demonstrated insights from diverse disciplines.

3. Systematic Literature Review

This systematic literature review delves into different bodies of work of articles and books on STEAM (Science, Technology, Engineering, Arts, and Mathematics) education in the context of secondary schools. STEAM education is recognized as a fitting response to the challenges of the 21st century, and STEAM learning emerges as a pedagogical method that connects necessary and crucial skills for learning development. The majority of sources collected indicate that adopting STEAM enhances creativity, problem-solving abilities, scientific inquiry, critical thinking, and other cognitive advantages among learners. The literature explores the positive influence of STEAM learning displaying how students are actively learning and centred around a student-learning approach. When teachers integrate STEAM, it is found to positively impact children through enhanced professional learning. The literature also explores how when students learn through STEAM it can contribute to boosting their self-confidence, integrating a spectrum of skills, and building knowledge about the world. The goal of this systematic review is to explore progressive learning approaches in education when incorporating STEAM.

3.1 Introduction

STEAM is an educational strategy that combines insights from science, technology, engineering, arts, and mathematics to tackle real-world issues encountered by students. This approach aligns with the contemporary necessity for comprehensive and interconnected learning essential for navigating the complexities of the 21st century (Yakman & Lee, 2012). Due to the rapidness of science and technology, educational trends need to be in pace with these fields. This leads to change and people need to adhere to these changes to develop. When viewing education, these rapid changes need to commence from early childhood in the curriculum and learning

environment (Draper & Wood, 2017). Early childhood education needs to utilize new tools and methods to encourage new skills such as creativity, critical thinking, collaboration, communication, technology skills, social skills, and knowledge. All these skills are vital and should be guaranteed from a young age to develop their skills and knowledge for the future. Children have a hard time learning from traditional approaches, but by using and implementing new methods children will have a better grasp and understanding (Purakom & Soykeree, 2017). This type of education offers students the essential knowledge and interdisciplinary view to solve a problem (Vasquez, et al. 2013). Therefore, art-based methods are as important as science or math and this mindset needs to be shifted and added in STEM to become STEAM (Dejonckheere, et al. 2016). This approach is gaining momentum globally with promising outcomes reported across various educational settings. Many countries are actively promoting STEAM integration across all levels of education. Integrated STEAM education is often regarded as a more holistic and well-rounded approach compared to its predecessor, STEM.

STEAM education has become more popular and relevant in today's education, where many researchers and studies have depicted the importance and benefits of integrating STEAM education in curriculums which was first introduced in Indonesia and the United States in 2007 (Perignat & Katz-Buonincontro, 2019; Han & Lee, 2012). STEAM education teaches through activities from all grade levels, from kindergarten to post-doctoral studies. STEAM education promotes optimistic results for students learning. Jolly (2016) describes how STEM and STEAM are competing against each other, however, they should not be competing they should rely on each other and show the strengths of each subject. Teachers and educators consider when learning through STEAM, students will be more involved and enthusiastic about the lesson and develop their critical thinking skills (Tippett & Milford, 2017).

To progress towards the inclusion of arts within integrated STEAM education, it's imperative to clarify their current status. This demands a comprehensive understanding of how arts are integrated into STEAM initiatives to fully influence their educational potential. This study undertakes a systematic review of STEAM proposals targeting secondary education levels, where the theoretical foundations of STEAM have seen notable advancements. The goal is to discern the attributes of STEAM educational plans concerning arts education and evaluate the influence of integrated STEAM education on the development of artistic competencies. Many research findings have linked the importance of introducing new and creative methods in education, and highlight the necessity of adapting to the constantly changing interdisciplinary approaches in teaching. This new adaptability to teaching and learning is influenced by technological advancements and socio-cultural and political factors. This change is seen as fundamental for equipping both learners and educators to succeed in an evolving world depicted in studies by OECD (2019), Schleicher (2018), and Tait & Faulkner (2016).

3.2 Research Questions

This dissertation aims to contribute to the understanding of STEAM education by examining various qualities and dimensions. STEAM education represents an interdisciplinary approach that integrates these core disciplines, fostering creativity, critical thinking, and innovation among students. Despite its growing popularity, there remain significant gaps in our understanding of the effectiveness, implementation, challenges, and broader implications of STEAM education. Therefore, the research questions presented below have been formulated to guide the inquiry into STEAM education and to address these complexities.

RQ1: How do existing educational policies and frameworks support or hinder the implementation of STEAM education initiatives?

RQ2: What professional development opportunities are necessary to support teachers in effectively implementing STEAM pedagogy in their classrooms?

RQ3: What is the impact of integrating art-based methods within STEAM education on students' engagement, creativity, and interdisciplinary learning outcomes?

RQ4: How do educators perceive the role of art-based approaches in enhancing STEAM education, and what are the challenges and opportunities they encounter in implementing such methods effectively?

RQ5: To what extent does the incorporation of art-based activities in STEAM education foster critical thinking skills, problem-solving abilities, and innovative thinking among students, and how do these outcomes compare to traditional STEM-focused approaches?

These research questions outlined above allow for the exploration of the multifaceted nature of STEAM education and its potential impact on student learning. This dissertation attempts to obtain information from other researchers, articles, and books to portray the effective implementation of STEAM education and investigate its implications to prepare students for future success and contribute to broader educational goals.

3.3 Methods

A systematic literature review provides an overview of the literature in a particular field, including the main ideas, models, and debates (Petticrew & Roberts, 2006). Systematic reviews aim to compile the results of numerous primary research studies on a particular subject while attempting to minimize both bias and random error (Cook et. al, 1997). This thesis aims to conduct a systematic literature review that examines studies related to STEAM learning in secondary schools. The literature was chosen from online sources, including books and journal articles. Searches were conducted through JSTOR, SCIENCE DIRECT, ERIC, and Scopus indexed open access journals, using keywords such as STEAM education, art education, art-based methods, STEAM integration/implementation, art in STEAM, and STEAM in secondary schools. These terms were strategically chosen to enhance the precision of the search to capture the importance of STEAM education. The specific terms and their combinations were adjusted as needed for different

databases to ensure a comprehensive and targeted search. The sources found were mostly published between 2007 and 2023. A summarized table is displayed below when searching for literature regarding STEAM education.

Year of Publication	2006-2023
Databases	JSTOR, SCIENCE DIRECT, GOOGLE, SCOPUS, ERIC
Types of Document	Books, articles, chapters
Subject	STEAM education
Keywords	STEAM, art integration, art-based methods, STEAM integration/implementation

Table 1: The chosen literature for the systematic review

After examining the titles, abstracts, and keywords of articles, the following criteria were used for inclusion: Articles must contain the specified search terms in their titles, abstracts, or keywords. The focus of the article should be on STEAM education. The article should focus on integrating STEAM and implementation with primary or secondary education students. Articles should discuss art education and using different art-based methods in STEAM, and lastly, articles should examine the outcomes and challenges of STEAM education. Following this process, after researching, collecting literature, and reading through the literature, 172 articles were selected and used for full-text examination regarding the mentioned criterion.

3.4 Results

Certain articles and books were reviewed and examined to be used for this review. The sources used were assessed for relevancy to the topic of STEAM education and art integration. Articles and a few books, which accumulated to pieces of literature, were utilized and coded to find similarities. The table below depicts the categorization of the goal of STEAM education, challenges of STEAM, different STEAM definitions, art in STEAM, art education, STEAM integration, art-based research and methods, STEAM implementation, and STEAM outcomes. Coding and

categorizing were the most appropriate and applicable approaches to analysis. Table 2 demonstrates the sources used to acquire the relevant information.

Section	Results	n	Example Sources
Goals of STEAM education	An approach to promote new insights and creations by combining STEM subjects and the arts. STEAM develops students' creativity, problem-solving skills in real-world settings, and active learning.	24	Kant et al., 2018; Quigley & Herro, 2016; Bush et al., 2016; Sharapan, 2012; Keane & Keane, 2016; Peppler & Wohlwend, 2018; Katz-Buonincontro, 2018; Long & Davis, 2017
Different STEAM Terms	Transdisciplinary STEAM education implies the complete integration of all disciplines.	49	Liao, 2016; Glass & Wilson, 2016; Quigley et al., 2017; Chung et al., 2022
	Interdisciplinary learning integrates multiple academic disciplines into a unified educational approach.		Togou et al., 2020; Lu & Ma, 2019; Maeda, 2013; Nguyen et al., 2020
	Art integration is a teaching approach where students learn and understand through art.		Silverstein & Layne, 2010; Marshall, 2014; Long II & Davis, 2017; Perignat & Buonincontro, 2018; Yakman, 2008; Yakman & Lee, 2012
Different Art-Based Methods	Performing Arts: Students can collaborate, present, attain confidence in learning, and improve their communication skills.	17	Colucci-Gray et al., 2019; Segarra et al., 2018, Novák, 2019.
	Visual Arts: Visual arts allow children to observe two-dimensional and three-dimensional works which improves effective learning and engagement in STEM disciplines.		Camargo et al., 2020; Chen & Huang, 2020; Oh et al., 2013; Timotheou & Ioannou, 2019; Wang et al., 2018
	Music: Enhance students' attitudes toward the subject and offer an authentic and creative learning experience.		Wellington et al., 2020; Milne & Calilhanna, 2019; Engelman et al., 2017
STEAM Integration & Implementation	Proper and positive implementation of STEAM in elementary, secondary, and university settings.	31	Boice et al., 2021; Mastrorilli et al., 2014; Mishra & Henriksen. 2013; Art, 2013; Marmon, 2019; Boytchev & Boytcheva, 2020; Madden et al., 2013; Delaney, 2014; Tesconi & de Aymerich, 2020; Callahan, 2019; Morton et al., 2017; Park, 2014; Timotheou & Ioannou, 2019; Zaratin, 2020
STEAM Outcomes	Creativity involves the conceptualization of new ideas, originality, and purposeful uniqueness	51	Lutenist, 2012; Friedman, 2010; Kampylis & Berki, 2014; Taylor, 2016
	Collaboration promotes group learning by aiding and developing students' thinking, oral communication, and leadership skills.		Bequette & Bequette, 2012; Guyotte et al., 2014; Hattie, 2012; Tait & Faulkner, 2016
	Innovation encourages students to tackle challenges in their learning and problem-solve in diverse ways.		Ritchhart, 2015; Wagner, 2012; Meyer & Turner, 2006
	Design Thinking is a method used for creative problem-solving and is found in STEAM education		Bush et al., 2016; Gross & Gross, 2016; Boy, 2013; Brophy et al., 2008
	Project- Based Learning allows students to engage in real-world projects to deepen their understanding and knowledge		Knapp, 2018

Engagement- Effective STEAM education programs must prioritize student engagement through the use of hands-on and real-world activities	Engelman et al., 2017; Upitis, 2011
Critical thinking is when students apply their existing knowledge.	Demirel, 2012; Seferoglu & Akbıyık, 2006; Howard et al., 2015
Growth mindset theory explains an individual's abilities and intelligence can be developed through hard work, and learning from failure	Dweck, 2006

Table 2: Results of Systematic Review on STEAM Education. Source: (Author)

3.5 Discussion

3.5.1 Goals of STEAM Education

Two main perspectives emerge regarding the purpose of STEAM education. The first perspective highlights the integration of broad skills such as creativity, problem-solving, interdisciplinary knowledge, and encouraging innovative ways of understanding. Shifting from STEM learning to STEAM, there was a strong prominence on engaging minority and female students. For instance, Kant et al. (2017) conducted an empirical study focusing on Native American girls, claiming that STEAM education promotes interest in STEM studies and careers among indigenous students. Similarly, Quigley and Herro (2016) mention STEAM's goal of involving the arts to attract students who typically shy away from STEM fields. Bush et. al (2016) discuss how mathematics-focused STEAM projects, highlighting the emerging literature on integrating arts into STEM engage diverse learners. Keane and Keane (2016) stress the need for all students to develop mathematical, scientific, and creative skills for increasingly technology-driven jobs. Sharapan (2012) explains how STEAM integrates arts into STEM curricula to facilitate children's expression of STEM concepts. Peppler and Wohlwend (2018) argue that STEAM approaches promote new insights and creations that transcend individual disciplines by combining STEM and the arts. Studies demonstrate that STEAM education develops children's active engagement and empowers them to take initiative in applying their knowledge to boost their self-confidence (Wahyuningsih et al., 2018). Kim and Kim (2016) propose three key learning criteria

for STEAM education: situational context, creative problem-solving, and emotional engagement. The situational context involves experiencing the need to solve real-world problems, creative problem-solving encourages students to develop their solutions, and emotional engagement sparks students' enthusiasm for tackling new challenges through interest, motivation, and the satisfaction of success. Bequette and Bequette (2012) advocate for seeing arts as a valuable goal in STEAM education because it promotes cross-disciplinary learning in various educational settings. Gettings (2016) stresses STEAM's potential for contextual learning by overlapping subjects to deepen understanding. STEAM education embraces a holistic approach to learning by catering to the needs of the *"whole child"* by addressing their social, emotional, and academic requirements (Connelly, 2012; Katz-Buonincontro, 2018). This educational framework has the potential to cater to individual student needs due to its student-centered and open-ended nature, providing multiple entry points for students of varying abilities and levels of proficiency. Ejiwale (2012) emphasizes the importance of offering open-ended learning activities, granting students the freedom to explore and experiment based on their interests and learning preferences. Long II and Davis (2017) emphasized the significance of STEAM education in society stressing its role in nurturing innovation and fostering creative problem-solving skills among students. Anthony and Ogg (2019) illustrated how STEAM education facilitates a deeper comprehension of science through its practical applications in real-world contexts. Jamalian (2018) argued that integrating arts into STEM disciplines empowers learners by stimulating problem-solving abilities and encouraging creativity. Furthermore, Mace (2018) suggested that STEAM education promotes collaboration, widens the scope of artistic expression, and enhances female participation and engagement in STEM subjects. Implementation of STEAM education at a college level, as seen at RISD, has allowed graduates to excel in both traditional arts and nontraditional fields promoting their artistic perspectives effectively (Allina, 2018). The STEAM curriculum at RISD encouraged innovation

by implementing an empowerment-focused approach. The RISD model facilitates individual agency, enabling students to acknowledge and embrace their unique perspectives in creative and critical thinking (Allina, 2018). STEAM education displays an open-ended inquiry approach and offers numerous benefits. Leszczynski et al. (2017) identify both advantages and challenges associated with this approach, firstly, students may experience feelings of uncertainty and confusion. However, the nature of open-ended inquiry-based projects parallels the real work of scientists, requiring collaboration, resource allocation, and interdisciplinary problem-solving (Leszczynski et al., 2017).

Presently, there is a scarcity of research tackling the development process and efficiency of STEAM-based curricula, as noted by Ghanbari (2015) and Herro and Quigley (2016). Herro and Quigley (2016) show the scarcity of in-depth documentation on STEAM education, therefore, they conducted a case study involving middle school teachers' perspectives regarding STEAM. Ultimately, there is a pressing need for case studies focusing on elementary or secondary-level STEAM-based institutions or programs, specifically examining curriculum and instruction, to provide educators with a workable model for STEAM education. As much as researchers strive for STEAM education to be implemented in schools there are many challenges that teachers and educators face. Norton and Hathaway (2015) explain that teachers have a difficult time being creative and innovative in their classrooms and Kirschner (2015) agrees with this concept because he posits how 21st-century education is challenging and the traditional forms of education are being left in the past for advanced forms of teaching. Consequently, 21st-century teachers need to be imaginative and inventive in their teaching to have a creative learning experience for their students (Henriksen, et al. 2019). STEAM education needs to have a design structure to benefit the students and teachers and teachers need to come together to find better ways and ideas to integrate STEAM

into curricula focusing on students' creativity, individuality, connecting them to real-life instances and experiences, project-learning, and cooperation (Sawyer, 2011; Henriksen, et al. 2019). Additionally, there are not enough tools and resources for teachers to fall back on when implementing STEAM into their classrooms (Henriksen, et al. 2019). Another aspect to keep in mind when trying to integrate arts into classrooms is the teachers with not much background in art. These teachers do not know where to commence when attempting to use arts in their classrooms, therefore, the school needs to aid these teachers with the proper resources, materials, and workshops to be accustomed to the arts. Sustainability is a crucial challenge for STEAM education because many innovative initiatives are run as part of after-school or summer youth programs and workshops. Programs within the school environment are often part of funded projects or short-term projects within schools participating in STEM/STEAM challenges (Chung et al., 2022). A coordinated approach that integrates STEAM learning into school-based curricula is recommended to ensure access for all learners and prevent the loss of potential from innovative initiatives. Another challenge is the need to enhance the overall quality of STEAM education research, particularly in studies focusing on the use of emerging technologies in STEAM education. As STEAM education is a relatively new and emerging field, these limitations are not unexpected, but their identification emphasizes the crucial need for adopting robust methodologies to study the effects of emerging technologies on students' learning in STEAM education. The present research also has limitations. Some extracted studies lacked adequate reporting of settings, study design characteristics, and participant demographics, restricting the depth of inferences that could be drawn. The emerging nature of the field may have resulted in incomplete capture of instances of good practice due to poor dissemination and recording, despite efforts to include grey literature, selective publication bias could still be a factor.

3.5.2 Different STEAM Terms

Transdisciplinary Learning

The majority of the articles initially introduced the concept of STEAM as an acronym for Science, Technology, Engineering, Arts, and Mathematics. However, there are various descriptions of the STEAM concept in the reviewed literature, three terms were identified: transdisciplinary, interdisciplinary, and art integration (Marshall, 2014). Transdisciplinary STEAM education involves the complete integration of disciplines without any boundaries, with lessons dealing with authentic problems or inquiry (Liao, 2016; Glass & Wilson, 2016; Quigley et al., 2017). Chen and Huang's (2020) unit primarily focused on students' knowledge of transportation but drew on aspects from other disciplines, qualifying as transdisciplinary. Kim and Park (2014) posit that STEAM education should witness the convergence of five domains within a single class, emphasizing problem-solving rather than a mechanical combination of disciplines. Some studies, despite articulating the goal of applying prior knowledge, appeared to mechanically combine different STEAM components. For instance, in developing an iSTEAM course for high school students studying electronic science and engineering, Chung et al. (2022) set learning goals encompassing all disciplines, requiring students to apply existing knowledge and develop new knowledge. Whether classified as transdisciplinary or interdisciplinary, these studies serve as examples of explicit integration of the STEAM approach across various disciplines. STEAM is not solely interdisciplinary but can also be characterized as transdisciplinary, as it surpasses the confines of individual disciplines (Costantino, 2018; Herro & Quigley, 2016; Kreber, 2008). Within a transdisciplinary framework, students possess the ability to apply their knowledge across disciplines and tackle creative challenges both within and beyond classroom settings (Gess, 2017; Liao, 2016). STEAM equips students with skills such as critical thinking, problem-solving,

collaboration, communication, creativity, and innovation, which can be transferred to diverse contexts (Liao et. al, 2016). The transdisciplinary approach in STEAM education is highly esteemed by educators and learners alike, as it enables students to approach problems or design processes from multiple perspectives applicable to real-world scenarios (Costantino, 2018). However, implementing a transdisciplinary approach in the classroom can pose challenges, as teachers need expertise across various content areas to create authentic learning experiences (Herro et. al, 2017). Kim et al. (2019) introduced a center as an institute for transdisciplinary arts-STEM collaborations, emphasizing the rarity of opportunities for collaboration between musicians, technologists, and research institutions, and the significance of accessible opportunities for such open-ended and long-term collaborations. Scholars such as Gulliksen (2016), Pallasmaa (2009), and Patton & Knochel (2017) have underlined the importance of engaging the sensory aspect of learning by suggesting that it plays a vital role in understanding our physical and mental capacities which is essential for human exploration, inquiry, and innovation. Insights into transdisciplinary STEAM practice draw from Carol Dweck's (2008) research on growth mindsets displaying that STEAM skills can be nurtured and developed. Perignat and Katz-Buonincontro (2019) distinguished between transdisciplinary and interdisciplinary STEAM studies, with the former fully integrating all components for authentic problem-solving and inquiry.

Interdisciplinary Learning

A study by Togou et al. (2020) deems STEAM as more interdisciplinary as they taught physics and math concepts to students through the engineering design and fabrication of 3D mini rockets. This complexity arises from the traditional structure of education, which often compartmentalizes subjects. STEAM, a combination of STEM and art and design thinking, signifies the integration of artistic and design perspectives into an interdisciplinary curriculum

encompassing science, technology, engineering, and mathematics (Lu & Ma, 2019; Maeda, 2013). Art-based methods promote interdisciplinary learning by combining the analytical thinking of STEM with the creative thinking of the arts. Teachers appreciate that this approach helps students make connections between seemingly unrelated subjects. Interdisciplinary learning, which integrates multiple academic disciplines into a unified educational approach, is strongly grounded in various educational theories that emphasize the importance of holistic and interconnected knowledge acquisition. This perspective aligns with interdisciplinary learning, as it encourages students to connect concepts from diverse subjects, enabling them to build a comprehensive understanding of complex issues. By synthesizing knowledge from various disciplines, students can engage in creative problem-solving and critical thinking, hallmarks of Piaget's constructivism. Interdisciplinary learning mirrors this concept by creating socially enriched learning environments where students collaborate, share ideas and learn from one another's perspectives. Interdisciplinary learning recognizes and accommodates these varied intelligence by allowing students to engage with subjects in ways that resonate with their unique strengths. Interdisciplinary learning emphasizes the collaboration and integration of knowledge across different disciplines to provide a holistic perspective (Nguyen et al., 2020).

Arts Integration

Many authors use the term arts-integration, Liao (2016) states that arts-integration is a pedagogical approach predating the concept of STEAM and warns against potential confusion when discussing the same content and ideas under different terms. Arts integration is a teaching approach wherein students construct and demonstrate understanding through art. Through a creative process, students connect an art form with another subject area achieving objectives in both domains (Silverstein & Layne, 2010). Marshall (2014) characterizes Silverstein and Layne's

definition of arts integration as multi-modal arts-based learning, which exceeds the notion that art production merely serves as a teaching and learning strategy for other subjects. Marshall further suggests that arts integration constitutes a transdisciplinary field because it exceeds disciplinary boundaries. The inclusion of arts (A) in STEM transforms STEM into STEAM, emphasizing the importance of creativity, artistic expression, and holistic learning in STEM education (Long II, Davis, 2017; Perignat & Katz-Buonincontro, 2018). The theory of Multiple Intelligences, developed by Howard Gardner, defines the existence of eight distinct intelligences: *"naturalist, spatial, linguistic, intrapersonal, interpersonal, musical, logical-mathematical, and bodily-kinesthetic"* (Gardner, 1983). Gardner challenges traditional views by asserting that individuals possess a broader range of abilities and are not confined to a single intelligence. This theory emphasizes the connection of these intelligences and their application in problem-solving and understanding diverse content areas (Rabalais, 2014). Gardner suggests that individuals can draw upon one or multiple intelligences to tackle tasks, theorize solutions, and navigate different domains which raises a holistic approach to learning (Gardner, 2011). STEAM represents an instructional approach centered on the advantages of integrated learning. However, in practice, the arts are often sidelined within arts integration practices in mainstream classrooms focusing on the 'core' subject(s) (LaJevic, 2013). Furthermore, according to Riley (2013), the arts are frequently relegated to enhancing lessons rather than serving as a means of fostering understanding and communication. Despite the positive claims regarding the significant benefits of integrating the arts into STEM education (Catchen & DeCristofano, 2015), many within STEM fields perceive the arts as lacking objectivity. This perspective may contribute to a lack of enthusiasm to embrace the term STEAM because it removes the attention from STEM (Dunning, 2013; May, 2015). Educators should approach discussions of STEAM with concern, especially using the term art integration because it can demonstrate the arts not as a distinct subject area, but merely as a tool for teaching

STEM subjects. When stressing on the term arts integration within STEAM it could lessen the idea that all subjects should be regarded as equal within the framework of arts integration.

Many articles discuss the integration of arts education typically refer to including visual or performing arts, design processes, techniques of various mediums, and critiquing final products. This perspective values the arts for fostering imagination and expressivity, with an emphasis on introducing new concepts and possibilities. Some of these articles also refer to National Core Arts Standards or Studio Habits of Mind, which are specific habits identified by art educators to promote creativity and skill development in art classrooms. Some articles explain that the purpose of incorporating the 'A' in STEAM is to encompass non-STEM disciplines such as the liberal arts and humanities. Yakman (2008, 2012) introduces the concept of STEAM, written as STΣ@M, from the perspective of an integrated curriculum. In her framework, an integrated curriculum breaks away from the limitations of discipline-based education. STΣ@M offers a structured curriculum framework that integrates traditional academic subjects within an interdisciplinary context. She defined it as *"Science and Technology, interpreted through Engineering and the Arts, all based in a language of Mathematics"*(Yakman, 2008, p.21). In this perspective, the 'A' in STEAM includes all the arts, humanities, and social sciences which accents a comprehensive approach to the curriculum (Yakman & Lee, 2012). Yakman further argues for the significance of all subjects, and that students should be exposed to each. However, in the STEAM Pyramid framework by Yakman, these subjects are not equally prioritized; rather, they constitute one-fifth of an integrated curriculum still primarily focused on STEM disciplines. Yakman promotes the integration of various subjects through a shared project and allows individual subjects within the STEAM curriculum to be taught by different educators. Consequently, the implementation of this concept

may not be apparent to those without access to such professional development and curriculum resources, thus raising questions about its practical application in daily school curricula.

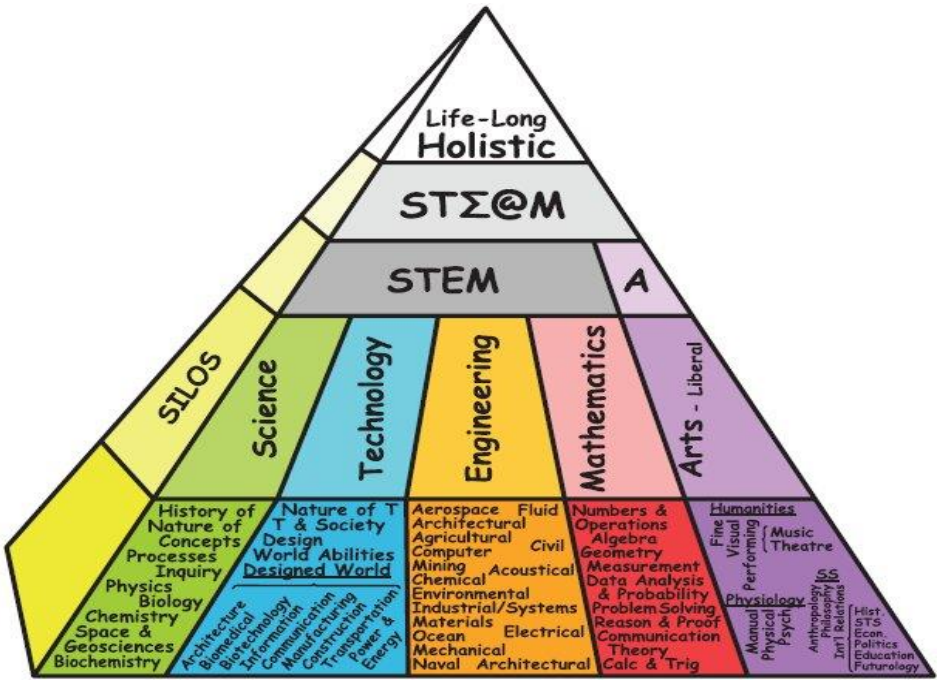


Figure 3: STEAM Pyramid. Source: (Yakman, 2008)

Quigley et al. (2017) distinguish between the plural 'Arts' referring to liberal arts disciplines, and the singular 'Art' encompassing visual, musical, and performance art. It's worth noting that this delineation differs from definitions provided by the National Coalition for Core Arts Standards (2013) and the National Art Education Association (2016). Clapp and Jimenez (2016) propose three interpretations of the 'A' in STEAM: arts as a discipline, arts as aesthetics, or arts as creativity and innovation in STEM. Some articles either lack a specific definition of the 'A' beyond the term 'Arts' or define the 'A' as 'Arts', but use it interchangeably with project-based activities, basic drawing or painting tasks, technology-based activities, or any form of building or making of a final project where students do not explicitly learn about the arts (Choi & Behm-Morawitz, 2017; Corbi & Burgos, 2017; Grinnell & Angal, 2016). In such cases, the concept of arts leans more towards technological aspects. Watson and Watson (2013) refer to "artistic

thinking" as the added 'A' in STEAM, aiming to stimulate innovative problem-solving through creative thought processes. Another example is an article by Moyer and Miller (2017), which describes a STEAM project focusing on environmental concerns and includes elements like painted rocks and a mural (used to conceal a propane tank), suggesting representation of the 'Arts' component within the project. Art is the application of human creativity, imaginative skills, and innovativeness. When art is implemented in education it can aid in the learning process through visual, tangible, and performing arts. This form of education has become popular and educators are portraying the importance of arts in education. Art education has a lot of benefits for the students, for instance, better cognitive skills, and improvement in comprehension, and communication. Gadsden (2008) expressed the significance of art by stating that by learning through the arts students approach learning from a different perspective and experience. It allows students to be more engaged in their learning and learn through multi-layered ways. Furthermore, Richard and Treichel (2013) discuss art integration as an,

> "Instructional approach used by teachers to work collaboratively to teach the content and processes of two or more subject areas, including one or more arts areas, and to increase the ability of students to identify, create, and apply authentic learning connections" (p. 224).

The goals of art are progressively expanding to hold not only the appreciation and production of artistic works but also design and media. Modern curricula now prioritize a comprehensive understanding and influence over the visual environment. While creativity remains a central theme, there is a growing emphasis on cognitive development. The curricula stress the practical relevance of the discipline in the professional world by seeking to distance it from its previous perception. Art educators aim to establish equal standing for art and design education alongside other fundamental disciplines. Consequently, curricula function as support tools by positioning the discipline as one that evolves and stays modern while being assessed by today's educational policymakers (Kárpáti, 2019).

3.5.3 Different Art-Based Methods

Art covers various forms, such as drawing, painting, sculpture, architecture, music, literature, drama, and dance. Art stimulates cognitive, social, emotional, and physical development (Doyle, 2017). Students actively participate in music by singing, listening, moving, composing, playing, and creating their instruments. Visual arts for students involve drawing, painting, and diverse artistic activities. Art enhances daily life, promotes thoughts and emotions, and contributes to holistic development (Maeda, 2013; Radziwill et al., 2015). Consequently, the question is how can an individual become a scientist, engineer, or mathematician without these basic art skills? It is very hard to imagine children and students not delving into and using arts in their studies. As Edwards (2010) stated art has five main components literature, drama, music, dance, and visual arts.

Performing Arts

Performing arts can highly benefit STEAM education because it allows students to collaborate, present, and attain confidence in learning. It improves their communication skills and go in hand with the scientific and technical aspects. One form of performing arts is theater, theater is a form of art where individuals can express themselves by acting in a variety of styles and methods that can be explained diversely among people. Theater is a great way to use in any science setting because it allows students to get creative and use acting as a way to understand and explain conceptual things; which leads to engagement to form discussions. This results in a student-oriented form of the classroom rather than a teacher-centered one because it allows the students to convey themselves and tell the story about a certain topic. Students can use a script provided by the teacher to re-enact a certain scenario, but students should have the competence and freedom to use improvisation. Improvisation allows students to create their understanding or ideas of a certain topic and gives students the tools to think and articulate quickly. Additionally, when using drama

it illustrates concepts or employs rhyming poems and songs for memorization purposes (Colucci-Gray et al., 2017). Thus, how can theater benefit STEM education? Primarily, the theater is a great way to use in any science setting because it allows students to get creative and use acting as a way to understand and explain conceptual things; which leads to engagement to form discussions. This results in a student-oriented form of the classroom than teacher-centered because it allows the students to convey themselves and tell the story about a certain topic. Students can use a script provided by the teacher to re-enact a certain scenario, but students should have the competence and freedom to use improvisation. Improvisation allows students to create their understanding or ideas of a certain topic and gives students the tools to think and articulate quickly. The next form of art can be dance, dance is an excellent way for students to express themselves through movement. Movement can be used *"to convey the complexity behind human discoveries and knowledge in science"* (p. 3). The performing arts serve as a way for students to explore, interpret, and assess the significance of their creative endeavors, through this students can pursue their ideas and uphold their artistic vision (Michaud, 2014). The integration of drama into STEAM education fosters social interactions and collaborative activities among participants (Dorion, 2009). Additionally, Abed (2016) and Alrutz (2004) promote how drama develops collaborative learning experiences and boosts students' enthusiasm for scientific inquiry. Drama can serve as a channel for comprehending scientific concepts (Dorion, 2009) and illuminating the methodologies of scientific inquiry (McGregor, 2012, 2014). Cogswell and McLauchlan (2014) assert that drama serves as an effective pedagogical tool, enabling students to articulate their thoughts and convey information through artistic expression that complements cognitive processes. Drama activities in STEAM classes allow students to enjoy using tools and working in groups to become more motivated in a particular topic. In the Forum Theatre within the Theater of the Oppressed, students are encouraged to step into different roles, perspectives, and scenarios adopting a space where they can explore

and express their thoughts and emotions without fear of judgment. Through the theatrical medium, individuals can delve into challenging themes, personal experiences, or societal issues by using different characters and narratives that act as a buffer for open and honest self-expression. This creates an environment where students feel safe to share their feelings, ideas, and perspectives leading to a more inclusive and supportive educational setting (Novák, 2019).

However, the use of drama in the STEAM classroom also presents challenges, for example, not all students want or can participate, some students find it difficult to complete the activities, and do not have enough time, experience, and confidence. Through a variety of interdisciplinary studies, both students and teachers in the STEAM classroom can experience the power of attention to the social environment and the importance of interdisciplinary teamwork. The latest research in this area also shows that the drama-based practice used in teacher training can promote many aspects of higher education (Cziboly et al. 2021; Malinina, 2023). A significant contribution and less researched area of drama pedagogy to this STEAM concept is Dorothy Heathcote's expert drama curriculum (Heathcote & Herbert, 1985). The 'Mantle of the Expert' methodology of this model - in the 1980s – in an undiscovered way by STEAM researchers, runs parallel to the current outputs of STEAM classrooms. This pilot study shows that the distance between theory and real teaching can be overcome with drama-based pedagogy in teacher education. Lastly, drama in education can improve social, communication, and cognitive skills (Freeman et. al, 2003). Social skills are vital skills for students because they can express positive or negative emotions, protect themselves, or ask for help. If students cannot fully express themselves socially, it can be through drama (İşyar & Akay, 2017).

Visual arts

In the realm of visual arts within STEAM education, the integration often involves a utilitarian approach, as described by Wellington et al. (2020). This perspective emphasizes the use of visual arts as a tool for STEM learning rather than fostering the development of arts-related skills and competencies. An illustration of this approach is evident in the work of Kim et al. (2015), where the arts component involved drawing figures based on fixed instructions, resulting in predetermined visual outcomes. In other instances, drawing and modeling are incorporated in the initial stages of developing projects like robots, virtual reality (VR) games, or augmented reality (AR) environments. Visual representations, such as images or schematics, are utilized to plan and conceptualize the construction of objects (Camargo et al., 2020; Chen & Huang, 2020; Oh et al., 2013; Timotheou & Ioannou, 2019; Wang et al., 2018). Visual arts allow children to observe two-dimensional works, for instance, drawing and painting, as well as three-dimensional works such as models, sculptures, and tangible items. All these visual arts should be implemented because it promotes an effective learning experience in STEM disciplines (Wynn & Harris, 2012).

Music

Music stimulates inquiry, dialogue, and critical thinking (Segarra et al., 2018). Wellington et al. (2020) explored how incorporating music in digital technology and science in concepts like bodily movement, vibration, and sound can enhance intercultural connectivity. Music is usually linked with various coding and programming initiatives, often involving software applications (Milne & Calilhanna, 2019). Engelman et al. (2017) showcased that combining programming with music can enhance students' attitudes toward the subject and offer an authentic and creative learning experience. Additionally, McKlin et al. (2018) demonstrated how EarSketch, a collaborative learning tool, introduces programming through music remixing. Kritsis et al. (2018) show Leap Motion, a creative tool to learn science through musical activities. Wellington et al.

(2020) findings suggested a connection between science, music, and teaching using digital technologies. Music also stimulates inquiry, dialogue, and critical thinking (Segarra, et al. 2018). Chang and Chou's (2020) statistical analysis revealed a significant positive impact on students' creativity in science and technology when exposed to visuals and music.

3.5.4 STEAM Integration and Implementation

Boice et. al (2021) conducted a study using a mixed-method approach to investigate a yearlong STEAM teacher training program. The program involved STEM and arts teachers who collaborated to design and implement STEAM lessons in nine schools. The study focused on various aspects, such as the importance of STEAM teacher training, the teachers' insights into the training, challenges in implementing STEAM activities, and STEAM design. The study's findings demonstrated the positive impact of training for teachers and students, increased teacher collaboration, and higher scores for students who were exposed to STEAM. Similarly, Mastrorilli, Harnett, and Zhu (2014) piloted a study to research the impact of professional development training on art teachers and their students. The research investigated the nature of art implementation, its successes and challenges, the impact of teachers' instructional practices and knowledge in art, and the effect on students' achievement through art. This study involved 77 schools and the findings displayed positive outcomes on teachers' instructional practices and students' arts achievement. This research contributes to understanding the effects of professional development on arts education. Quigley and Herro's (2016) study investigates STEAM implementation in science and math middle school classes. The study offered research-based evidence for educators regarding STEAM. The study included 21 science and math teachers and utilized a qualitative methodology by using the teachers' reflections, observations, and field notes. The findings of the study portrayed how teachers had difficulty in incorporating the arts into their lessons and assessing the students,

but teachers displayed the importance of STEAM and its ongoing interest, collaboration skills, and the addition of technology. These studies boost the literature review because they display awareness of STEAM teacher training programs, their challenges, and their impact on both teachers and students. When understanding the successes and challenges in implementing STEAM education can create and design professional development initiatives. An article from UDIR (2019) emphasizes the importance of clear expectations and motivation in realizing students' learning potential. The article underscores the significance of having high yet realistic expectations of students, emphasizing that teachers must also set expectations for themselves. UDIR states that learning activities should include challenges and drive, highlighting how students' motivation and mastery can enhance concentration and reduce social and emotional difficulties. Professional competence, including both organized and flexible teaching, and a deep understanding of the class as a social system, is crucial for teachers. An engaged teacher can create curiosity and dedication. The article concludes by noting that being in a situation one doesn't master can weaken expectations of mastering and may lead to low motivation. Students facing a fear of failure might develop negative coping strategies, such as conflicts and disruptions, to avoid challenging learning situations. Mishra and Henriksen organized a study in 2013 that depicted STEAM activities and practices that promoted engagement among students and were more ambitious which led to an increase in their learning. Critical thinking comes into the picture for students' increase in their learning and is seen when doing STEAM activities. Through critical thinking, students can manage and practice their ideas creatively and unravel issues using innovative skills (Art, 2013; Marmon, 2019). Many activities are used to achieve STEAM goals which include museum visits, hands-on experimentation, engaging in interactive books, gamification, simulations, and video creation (Li & Wong, 2020). Gamification has been gaining prominence and is the integration of game elements into educational content (Boytchev & Boytcheva, 2020). Madden et al. (2013) and Ghanbari (2015)

discuss the emergence of STEAM models in higher education, piloted by industry leaders like Lockheed Martin, supporting a more holistic approach to education. Colleges and universities are attempting to integrate arts with STEM subjects through multidisciplinary programs and integrated courses. Some institutions focus on community-based learning to nurture creative scientists capable of tackling global challenges. Ghanbari (2015) highlights STEAM programs at the University of Texas-Dallas and the New York Film Academy collaborating with NASA. Madden et al. (2013) cite examples such as the State University of New York, Rhode Island School of Design, Maryland Institute College of Art, Bryant College, and Rensselaer Polytechnic Institute attempting STEAM implementation. For instance, the State University of New York at Potsdam, supported by Lockheed Martin, encourages creative thinking through the integration of arts, humanities, and STEM. Additionally, the Rhode Island School of Design offers integrated courses to link STEM and STEAM education. The Maryland Institute College of Art incorporates STEAM elements into its graduate research program. STEAM education is informally embraced and recognized as integral to art and design schools (Madden et al., 2013). In addition, several post-secondary institutions like Bryant College in Rhode Island merge creativity with business and engineering, focusing on fostering skills such as creative problem-solving, teamwork, and the innovation process. Rensselaer Polytechnic Institute offers programs in electronic arts, games and simulation arts and sciences, innovation, and society, incorporating assignments that integrate STEM into STEAM. Many post-secondary institutions aim to provide students with opportunities to develop creativity, innovation, and collaboration skills within the framework of STEAM education (Madden et al., 2013).

The implementation of STEAM education was also displayed in various elementary and secondary schools. There are a few approaches when implementing STEAM education, such as

fully integrating arts into STEM subjects, implementing STEAM curricula, establishing STEAM schools or classes, creating maker spaces for STEAM projects, or hosting workshops. However, the adoption of STEAM programs has grown in the United States, Canada, Europe, and Korea, for instance, Andover High School, Da Vinci Schools, Drew Charter School, Fisher STEAM Middle School, Quatama Elementary School, and Pulaski Middle School (Herro & Quigley, 2016, Delaney, 2014). For instance, Boston Arts Academy operates a STEAM lab, supported by a director, which enables teachers and students to explore the connections between arts, science, and math. The STEAM lab incorporates technologies like 3D modeling, electronics, and digital media.

The project Global Science Opera is an exemplary STEAM implementation, an initiative coordinated by Scientix a science education network in Europe. Each year, Scientix introduces a STEAM proposal for producing a science opera centered around a specific theme. Schools from various countries participate by creating their two-and-a-half-minute scenes, encompassing aspects such as scriptwriting, music composition, set design, and costume creation. This initiative includes metacognitive activities, such as visits to scientific institutions, virtual discussions, and inquiry-based or design thinking tasks (Tesconi & de Aymerich, 2020). Projects like the UK CREATIONS and "The Imagineerium" Sonic Pi in the UK point out the partnerships between teachers, artists, and science experts to integrate science and art through artistic mediums like dance, opera, visual arts, and theater. These projects allow students to engage in scientific exploration alongside traditional problem-solving and digital design approaches. Togou et al. (2020) study displays the Erasmus Newton project applying Fab Lab-based learning to enhance the interest and motivation of primary and secondary school students in science. Small workshops were designed and equipped with 3D printers and other computer-controlled tools for personalized digital creation, and students engaged in activities to develop their STEAM knowledge and skills. These investigations sought

to understand how exposure to emerging technologies could influence students' enthusiasm for various STEM fields. Other studies shared a common goal of observing the impact of STEAM on students' attitudes toward specific STEAM disciplines and future career possibilities (Callahan, 2019; Morton et al., 2017; Park, 2014; Timotheou & Ioannou, 2019). Furthermore, Hug et al. (2017a, 2017b) organized workshops for primary and secondary school children which aimed to establish connections between computational thinking and musical thinking. This approach resulted in students perceiving programming as less 'hard and boring'.

In the United States, collaborative projects such as RISD Lab provide students with transdisciplinary learning experiences. These projects allow students to explore abstract concepts through diverse inquiry methods in science, art, and design (Costantino, 2018). Another project named, GetWet, focuses on a water pumping station at a heritage site aiming to engage students in real-life contexts connecting science and technology (Colucci-Gray et al., 2017).

A study by O'Leary and Thompson (2019) employed a cluster random sample that assessed the impact of visual art, specifically drawing, on long-term retention of science subjects. The study involved 55 5th and 6th-grade students. The students were given tasks that incorporated visual arts into their science lesson. The findings suggested that visual art integration, particularly drawing, could promote long-term retention of STEM content compared to traditional approaches. O'Leary and Thompson's (2019) study demonstrates the potential benefits of visual art integration in STEM learning and student retention. This insight contributes to the broader understanding of interdisciplinary approaches by aligning with the exploration of STEAM perceptions among teachers and students in this research. This study links to the literature review because it accentuates the importance of policymakers evaluating and fully integrating interdisciplinary educational experience, more specifically the Arts.

Zaratin's (2020) qualitative case study aimed to show the process educators undergo when implementing a STEAM curriculum in a K-4 elementary school. The study sought to gain a deeper understanding of teachers' perspectives regarding an effective STEAM program. The study addressed what the requirements are for elementary teachers to successfully apply a STEAM curriculum in their classrooms. It explored teachers' understandings of elementary-level STEAM education, their confidence in teaching STEAM, and difficulties when applying STEAM. The sample consisted of five K-4 teachers participating in a STEAM initiative in a suburban New York elementary school during the 2019-2020 school year. The findings indicated that none of the reviewed lessons provided rich opportunities for inquiry-based STEAM learning, despite teachers using the term in interviews. Although technology was frequently used, mathematics, engineering, and arts were not observed. The study's limitations included potential bias in the focus group resulting in limited generalizability due to the small school district's regional biases and specific cultural contexts. Despite these limitations, Zaratin's (2020) study aided the dissertation by offering significant research on STEAM perceptions and its effective qualities with valuable qualitative insights. These examples showcase diverse approaches to STEAM education, emphasizing the importance of seamlessly integrating arts with science, technology, engineering, and mathematics in the learning process. The MoveLab study was designed to create a computing self-concept among underrepresented girls through technology-enhanced dance performance by being in collaborative groups. This was believed to be essential for building agency and a sense of empowerment, as evidenced by participants' statements, stressing how learning computation allowed them to support each other's learning processes (DesPortes et al., 2016). Graham and Brouillette's (2016) study examined the theory that the Arts could serve as a potent tool for upper elementary students. Additionally, the research delved into assessing the impact of STEAM lessons in physical science classes among students in grades 3 to 5. The study involved a lot of participants

starting with a cohort of 893 students across five schools, involved teachers who had undergone one year of training before the experiment. The second cohort, with 1,263 students, featured teachers engaged in co-teaching with teaching artists. The findings showed that when STEAM was involved in the lessons students had higher grades in physical science and found art integration to be beneficial to young English learners. This study merges well with the literature review because it promotes the use of art in classrooms and how adding the arts can aid in students' learning. In the context of developing the STEAM curriculum, teachers play a crucial role in designing and planning STEAM learning (Land, 2013). The involvement of teachers is vital for the success of such learning experiences where students benefit significantly from intentional, stimulating, and developmentally appropriate activities that specifically support their understanding of STEAM concepts (Aldemir & Kermani, 2016). Gábor Klima, a teacher at Eötvös József Secondary Grammar School, Budapest, conducted a school experiment about developing biology-oriented materials with visual culture tools and media to foster creativity and digital aptitude within science education (Needle et al., 2007). His research offered that when students creatively engage with biology topics it enhances comprehension, using qualitative and quantitative methods. Klima's research suggested that combining science with art pedagogy increases an awareness of environmental issues and population challenges. The research involved seventh-grade students from a secondary grammar school, focusing on biology topics related to environmental and social concerns. Students worked collaboratively and produced animations using paper cut and stop motion techniques to visualize environmental issues and societal dynamics discussed in biology classes. Klima stated that the integration of digital tools alongside traditional drawing methods enabled comprehensive visual skill development and provided an authentic learning environment. Additionally, lively discussions about sustainable practices stimulated critical thinking regarding consumption and its environmental implications. Therefore, Klima (2019) states that visual culture

is an effective discipline and digital tools offer an interdisciplinary methodology reshaping the role of art education in schools. Lastly, in the pilot study from Kasbary and Novák (2024), they conducted two STEAM activities integrating drama into a science and history lesson. The pilot study involved 19 first-year university students participating in these activities and the findings demonstrated a positive reaction from the students from participant observations. The pilot study's findings portray how students felt they could be as creative and imaginative as they want, have motivation to learn in the lesson, have problem-solving and thinking skills, and collaborate. The STEAM activities displayed the integration of drama in science by creating a dance or series of movements on the life cycle of a butterfly, and the second activity was integrating drama in history where students created a short skit regarding the Indian Caste System. This pilot was deemed successful because the students reflected upon the activity with positive feedback.

3.5.5 STEAM Outcomes

STEAM education objectives are to prepare children to think critically and creatively, cooperate, innovate, and use proper communication (Quigley & Herro, 2016). This is an important advantage to education because the world is developing so innovations must be created for the future. Sanders (2009) further explores this idea and states that the arts should be applied in math, science, and technology. The main concept of STEAM education is to include all forms of discipline in education by evenly delving into creativity, criticality, and analysis. Therefore, STEAM is meant to incorporate all subjects together to allow students to think differently, engage in problem-solving, cooperate, and be innovative. The arts can create new skills for students from problem-solving to critical thinking, inventiveness, group work, and having thorough discussions (Sousa & Pilecki 2013). The STEAM curriculum concentrates on student-direct learning where teachers and educators provide sufficient guidance with positive and useful criticism and feedback

(Madden et al., 2013). Therefore, teachers and educators are meant to change the aspect of teacher-centered classrooms to student-centered to give the proper knowledge and readiness for their future (Sousa & Pilecki, 2013; Darling-Hammond, 2010; Doniger & Sydow, 2016). According to Rolling (2016), he states how STEAM is important and quotes:

> "STEAM matters because we are more than just instructors of art and art education. While most of our students year in and year out will not become professional artists, we are nevertheless arguably the primary teachers of creativity our students will ever have throughout their education. Fundamentally, our job is to instigate and foster art practice and design thinking as a means for individual learning, social responsibility, and creative problem solving—mediating ideas and materials toward meaningful and enduring solutions " (p. 4).

Many studies focused on cultivating 21st-century skills, including persistence, creativity, and problem-solving, within the context of STEAM education. Several studies in the field of STEAM education focused on the development of 21st-century skills, including persistence, creativity, and problem-solving. The importance of cooperative learning in creative workshops is seen as influential in enabling active learning by empowering students and fostering a sense of respect among peers (Jesionkowska et al., 2020).

Creativity

> "Creativity is a key priority and STEM educators need to embrace the arts to foster students' creative design and performance, using various media: IT leaders should add an 'A' for fine arts to the science, technology, engineering, and math charter – STEAM, not STEM" (Peter Taylor, 2016, p. 126).

M.I. Stein, author of *Creativity in Culture* (1953) provides insights into the understanding of creativity. He emphasizes that creativity involves purposeful deviation from the existing norm and is problem-dependent. Creativity involves the conceptualization of new ideas, and when applying STEAM lessons it fosters creativity, originality, and purposeful uniqueness. Creativity, as defined earlier, doesn't involve judgment about the utility, practicality, or objective of ideas; it revolves around originality and meaningful thought. Kampylis and Berki (2014) explained that creative thinking gives students a chance to incorporate their imaginations into their subjects. Boy

(2013) also suggests that students need to cooperate to foster creativity and to share their skills and ideas of a certain subject. This promotes innovative ideas, new skills, and abilities. Critical thinking skills become crucial when students analyze their creative ideas and evaluate their relevance to the topic at hand. The integration of arts in STEM education provides knowledge from a unique perspective, enabling students to explore new solution sets and consider options not available in traditional STEM approaches.

STEAM education has demonstrated positive impacts on creativity, as seen in a study from the *Journal of Technology and Design Education* that implemented an effective STEAM activity resulting in increased verbal and figural creativity among a group of 7th-grade girls in Istanbul, Turkey. The study is titled *"Exploring the Effectiveness of STEAM design processes on middle school students' creativity";* where it compared a control group of students learning with a traditional science curriculum from a textbook and the group was exposed to the same content through varied STEAM-oriented lessons. The results indicated a significant difference in favor of the experimental group demonstrating enhanced verbal and visual creativity (Ozkan & Umdu Topsakal, 2019). Similarly, McKlin et al. (2018) investigated the impact of Earsketch on students' creativity and persistence in computer science portraying a commitment driven by identity/belongingness and creativity. Oh et al. (2013) observed enhanced creativity in elementary students following a STEAM program employing Scratch for game design and play. Sakon and Petsangsri (2021) evaluated their STEAM instructional model's effect on creativity in packaging design within a college-level computer graphic design course. Chang and Chou (2020) discovered that involvement in activities utilizing processing software and the Leap Motion sensor elevated the creativity level among science and engineering students (Perignat & Katz-Buonincontro, 2019). Deloitte's (2015) analysis of the future of information technology (IT) professionals argues that

creativity is crucial and should be prioritized. Taylor (2016) suggests that educators in STEM fields incorporate elements of the arts to improve students' abilities in creative design and performance, and suggests the inclusion of arts and advocating for STEAM rather than STEM.

Collaboration

Glăveanu (2011) advocates that collaboration is an intersubjective aspect where people's understanding, learning, and creativity join together to make a creative and cooperative effort. Guyotte et al. (2015) also support the concept of collaboration, in the context of engagement, as vital and a better way of learning than doing it individually. Students can put forth their narrative context in the class to their classmates and teachers and students become more engaged in the learning and creative experience (Thomas & Chan, 2013; Guyotte, et al., 2015). For educators in art and design, the concept of STEAM encompasses more than just enhancing STEM subjects with design skills; it entails collaborative efforts among educators across various disciplines (Watson, 2016). Art and design educators are encouraged to engage with their educators in STEM fields to explore how art can be integrated into the STEM/STEAM curriculum (Bequette & Bequette, 2012). Through these efforts, it promotes mutual learning between art and STEM instructors (Wynn & Harris, 2012). This approach emphasizes an interdisciplinary and collaborative perspective on STEAM entering into a transdisciplinary realm (Guyotte et al., 2014). Furthermore, Guyotte et al. (2014) state that a transdisciplinary STEAM curriculum can evolve into a form of social practice and facilitate collaborative creativity among students. Previous research also indicates that innovative educators gain confidence when receiving support from like-minded individuals who share unconventional perspectives which creates a unified team (Hattie, 2012; Tait & Faulkner, 2016). Scholars such as Dweck (2008), Wagner (2012), and Tait and Faulkner (2016) underline the significance of self-reflection in fostering innovative collaborations where educators can make

informed decisions based on both collective and individual insights rather than external influences. Wagner (2012) reminds us to not *"give in to the temptation that you can do this thing you want to do all by yourself. You can't"* (p. 245). Research on the impact of integrative forces in learning, as evidenced by Barniskis (2014) and Ritchhart (2015), highlights the significance of modeling as an implicit aspect of teaching. This implies that teaching is not solely about the demonstration, but also involves a "*continuum of explicit and implicit sharing of our identities as thinkers and learners*" (Ritchhart, 2015, p. 125).

Innovation

The establishment of innovative learning and teaching environments through transdisciplinary STEAM relies on the integration of diverse perspectives and expertise. Ritchhart (2015) and Wagner (2012) describe this transdisciplinary modeling as a dynamic process of creative inquiry and problem-solving, fostering a culture of motivated and innovative thinking. STEAM emphasizes the ethnography of teacher practice, including interactive modeling, embracing growth mindsets, and collectively constructing knowledge, ultimately leading to innovation (Meyer & Turner, 2006; Dweck, 2008). Research from Taylor (2016) and Wagner (2012) underscores the significance of generating new knowledge and experiences to tackle challenges, emphasizing that the practical application of knowledge is paramount.

Design Thinking

Design Thinking is a method used for creative problem-solving and is found in STEAM education (Bequette & Bequette, 2012; Bush et al., 2016; Gross & Gross, 2016). Design thinking refers to the cognitive processes and problem-solving skills utilized by designers in their professional practice (Watson, 2015). Donar (2011) identifies and investigates the nature and pedagogy of design thinking, and how it is a growing trend towards a more integrated, cross-

disciplinary, and holistic approach. Design thinking has garnered increasing attention for its application in integrating STEAM principles into engineering domains, although it also serves as a standalone framework applicable across the arts and sciences. Notably, both engineers and visual artists can employ design thinking methodologies (Boy, 2013; Brophy et al., 2008). The Stanford School of Design has developed the Stanford design model which is one of the most recognized and widely used, this model served as the guiding framework for teachers as they re-created their curriculum to incorporate STEAM principles (Plattner et al., 2015).

Project-Based Learning (PBL)

An instructional approach where students engage in real-world projects to deepen their understanding and apply knowledge and skills. PBL is foundational to effective STEAM education, promoting creativity and a departure from traditional teaching methods (Adams, 2005). PBL provides an alternative approach to traditional teaching methods and can foster creativity, critical thinking, and collaboration among students (Knapp, 2018). Researchers (Kokotsaki et al., 2016; Krajcik & Blumenfeld, 2006; Larmer et al., 2015) have presented similar attributes to the effectiveness of PBL on how it fosters the exploration of authentic questions and issues, prompting students to utilize their conceptual understanding of subjects and link it to practical applications. Grant (2011) identified that PBL has improved student motivation by emphasizing the role of cooperative learning techniques. Ilter (2014) also depicted the positive effect of projects on cooperative learning and the development of students' theoretical understanding and academic motivation. Larmer et al. (2015) support PBL by stating when implementing it in the classroom students will acquire authentic learning, examine essential questions, and apply real-world content. Research conducted in 2014 demonstrated that students displayed greater success in college when their high school experiences involved a student-centered instructional approach, including project-

based teaching, collaborative learning, and performance-based assessments (Friedlaender et al., 2014). Al-Balushi and Al-Aamri (2014) showed an investigation involving sixty-two 11th-grade female students in Oman participating in environmental science projects. The outcomes revealed significant advancements in both environmental knowledge and enthusiasm for utilizing new technology in designing their projects.

Engagement

Artistic activities like drawing, painting, or creating music can engage students in ways that traditional lectures and textbooks may not. Teachers notice that students become more enthusiastic about STEM topics when they are presented in a visually or aurally appealing manner. Engagement in education is a dynamic concept that exceeds both old and new educational theories while being continuously informed by cutting-edge research. Engelman et al. (2017) examined the impact of engagement with emerging technology, specifically Earsketch, on students' creativity, persistence, and attitudes toward computing. It prompts students to construct their understanding through active exploration and making connections with the subject matter. Guyotte et al. (2014) perceive STEAM as a social practice characterized by active engagement with materials, consideration of audience, and interaction with the community, aligning with the notion of students actively sharing their learning experiences and outcomes. Engaging with a broader community and having the chance to showcase their work enables students to imbue their designs with greater intentionality. It also allows them to articulate their thought processes and reflect on feedback received from others. Upitis (2011) emphasizes the centrality of student engagement in learning and underscores the arts' role in fostering engagement by encouraging cognitive learning, collaboration, and emotional connection with concepts.

Critical Thinking

Demirel (2012) characterizes critical thinking as when students apply their existing knowledge and modify it through evaluation. Fundamentally, critical thinking involves the capacity to scrutinize events, conditions, or ideas and make judgments while evaluating the reliability and validity of information using logical and intellectual standards (Seferoglu &Akbıyık, 2006). This advanced cognitive skill allows individuals to examine and fix errors and shortcomings in current knowledge or situations, leading to appropriate solutions (Howard et al., 2015). Critical thinking skills embody tasks like recognizing and analyzing the credibility of information sources, establishing connections, and drawing conclusions (Thurman, 2009). In summary, the defining features of critical thinking involve- engaging in reasoning and skepticism, studying situations from various perspectives and dimensions, being open to change and innovation, resembling thoughts without preconceived notions, maintaining an open-minded attitude, thinking analytically, and lastly paying attention to details. Critical thinking brings forth advantages such as individuals' ability to think independently, steer clear of impulsive behavior, and articulate problems (Demirel, 2012). From an educational viewpoint, it becomes necessary to adopt both critical and creative thinking skills. These skills empower individuals to assess and analyze discussions, obtain meaning from observations, engage in thorough reasoning, and critically evaluate assumptions across diverse fields.

Growth Mindset and Real-Life Applications

Lastly, STEAM education can effectively grow the students' mindset. Carol Dweck's groundbreaking work on the growth mindset theory theorizes that individuals who believe that their abilities can be developed through dedication and hard work are more likely to embrace challenges and persist in the face of setbacks (Dweck, 2006). The arts associate effortlessly with this theory by encouraging students to view mistakes as opportunities for growth. In the process of creating

art, students often encounter obstacles, make revisions, and learn from their errors. These experiences foster a resilient attitude and a willingness to tackle complex tasks. The arts cater to this theory by providing a variety of opportunities for students to express their understanding and creativity. Students with varying talents, whether in visual arts, performing arts, or creative writing can find a platform for their unique abilities. This diversity in artistic expression reinforces the idea that growth and development can occur in different forms promoting a comprehensive understanding of the growth mindset. Art-based methods encourage students to take ownership of their learning by setting goals, reflecting on their progress, and making adjustments as necessary. Therefore, fostering a growth mindset is proved by contemporary educational theories that stress the importance of embracing challenges, recognizing diverse talents, and promoting self-regulated learning. This approach supplies students with a broader perspective on personal development, flexibility, and the belief in the power of effort and dedication.

3.6 Conclusion

In conclusion, the synthesis of diverse scholarly perspectives presented in this literature review demonstrates the potential of STEAM education within contemporary educational settings. The discourse surrounding STEAM pedagogy illustrates its capacity to promote multidimensional competencies essential to skills of the 21st century. As seen throughout the literature review, educators and researchers depict the benefits of integrating STEAM education in schools, however, there also exists an apparent acknowledgment of the challenges to effective implementation. This review sought to provide a nuanced understanding of STEAM's efficacy in developing learning experiences, 21st-century skills, and stimulating innovative approaches to education. The literature portrays divergent perspectives and theoretical frameworks for STEAM education transcending disciplinary boundaries and fostering intellectual growth and creativity. Land (2013) demonstrates

the positive arguments for STEAM that it unifies students' thinking, artistic disciplines, and self-motivation. Furthermore, Yakman and Lee define STEAM education as, "*the interpretation of science and technology through engineering and the arts (a century that covered the humanities was studied); all based on mathematical elements"* (p. 1076). Zamorano et al. (2018) express STEAM as an integrative aspect that merges sciences, technology, engineering, art, and math to aid in students' lives. White (2010) further states how adding the arts into STEM connects all these aspects and his views are that the arts are the main feature of creativity, creativity produces innovative concepts, and these innovations build for future industries, and with these modern and new industries promotes new jobs and boosts the economy (Marmon, 2019). Lichtenberg et al. (2008) defend White by stating the main value of art is creativity and that each person creates their process and skills (Feldman, 2015; Marmon, 2019). To integrate art into STEM education teachers need to design and create new objectives that target students' creativity and innovativeness through the STEM subjects. Through the process of design, creative problem-solving is introduced into the STEAM concept and in curriculum development. Teachers, when designing, begin contemplating and considering curriculum development; and students also have accessibility in the design process where they take this new design and implement change in their learning process. Students and teachers have a clearer objective of what they want in the classroom and can reshape the curriculum to be STEAM-based (Hoadley & Cox, 2009). This literature review portrayed different researchers' perceptions, purposes, and definitions regarding STEAM education and the effectiveness and outcomes of STEAM. The literature portrayed the advantages of art and how STEAM should be an integral part of today's education system starting from any educational setting. As popular as STEAM is, there are struggles and challenges to its implementation in the classrooms and curricula. STEAM practitioners are trying to promote the importance of STEAM and how the arts benefit students from collaboration, creativity, in-depth learning, and more. Therefore, to give equal

opportunity to the arts, educators need to add arts to STEM and shift it to STEAM (Herro et al., 2017). STEAM education can improve students' communication, critical thinking, and problem-solving skills by giving a hands-on experience with different topics. It also allows students to begin reflecting on their experience with STEAM activities have different interpretations and get feedback for their work which is vital in their learning development (Costantino, 2018). Lastly, this literature review depicted different academic settings where STEAM has been integrated and implemented into the lesson and the positive experiences teachers and students had from it. The impact of learning through STEAM allows students to be more active and take initiation of their knowledge, promotes cognitive outcomes, and positive connections, and increases self-confidence and engagement in the classroom. This review sought to set important precedence towards STEAM education. The analysis of the collected studies provides a comprehensive view of a dynamic, pedagogically advanced, and innovative landscape in STEAM education. Challenges and barriers to STEAM integration highlight the importance of evidence-based evaluation studies for effectiveness. Examining the motivations of STEAM education researchers reveals a broader conceptualization of learning beyond disciplinary skill sets, and STEAM education utilizes and addresses real-world problems, targets the development of critical 21st-century skills, and challenges traditional forms of participation. Few studies discussed future work, but one common recommendation was the need for more professional development in STEAM education to support teacher development.

4. Research Methods and Design

4.1 Introduction

The objective of this qualitative study is to investigate, comprehend, and reveal secondary educators' and students' viewpoints and encounters regarding STEAM education. This research has the potential to advance knowledge regarding the implementation of STEAM integration in secondary schools by examining the insights from educators and students. Raising awareness among educators of STEAM education and its methods can enhance its integration into curricula (Bell, 2016; Stubbs & Meyers, 2015; Zimmerman, 2016). Through this study, educators and students may gain a deeper understanding of the difficulties and benefits associated with integrating STEAM into classrooms. Furthermore, the findings of this study may assist future educators in developing and integrating STEAM practices in classroom settings from professional development. Additionally, it is important to inspect and evaluate the qualifications for effective instruction that influence secondary teachers' attitudes, perceptions, and confidence in implementing STEAM education (Wang, 2012). The identified themes aim to offer and depict a deeper understanding of the teachers' and students' personal thoughts about STEAM, alongside their practical experiences and after the completion of the STEAM activities from the researcher on how it impacts students' learning and teaching.

4.2 Qualitative Method

Chapter 4 provides a detailed account of the chosen research method and design depicting the reason behind selecting a qualitative design coupled with qualitative methods. This chapter explains the research questions, sampling criteria, participants, procedures for obtaining informed consent, measures to ensure credibility and reliability, and the geographic location of the study.

Additionally, it delves into the data collection procedures, the reason for these chosen methods, and the approach to data analysis. Qualitative research was chosen over quantitative research to hold various facets of a situation and define a comprehensive understanding of the main idea (Creswell, 2013). Stake (2010) explains qualitative research as a process aimed at gaining a deep understanding of a single phenomenon and how it operates. Qualitative studies are suitable when there is limited information about the topic, the variables are not well understood, and existing theoretical frameworks are insufficient (Yin, 2009). In qualitative research, establishing credibility involves guaranteeing that research results are perceived as believable from the perspective of the research participants. Yin (2014) advocates for the triangulation of multiple sources of evidence to enhance the credibility of a research. It is beneficial to obtain various sources of evidence from multiple participants for the researcher to identify themes and patterns. Research notes were utilized to capture reflective thoughts, questions, decision-making processes, and ideas throughout the data collection process (Merriam, 2009). In qualitative research, dependability is vital and should be achieved through the consistency of research findings. To create dependability, definite procedures and guidelines were established for data collection, documentation, and analysis. Participants were chosen to represent the broadest possible variation within the population (Merriam, 2009). Reliability in qualitative studies pertains to the consistency and dependability of the collected data (Yin, 2009). Elements such as trustworthiness, authenticity, and credibility contribute to reliability (Creswell & Miller, 2000). Credibility relates to the believability of the findings and is supported by evidence from the participants and theoretical notions (Merriam, 2002). The researcher will conduct data analysis to demonstrate a detailed depiction of the data and to certify credibility. Therefore, this research seeks and focuses on the outcomes of secondary teachers' and students' perceptions regarding STEAM education.

Data collected from the STEAM activities and field notes from student observations will be utilized to triangulate with the interview data. Through the analysis of these documents and interviews, patterns and themes are anticipated to surface (Yin, 2009). Triangulation is a method often applied to explore findings by integrating multiple data sources. Cohen and Manion (2000) defined triangulation as a means to comprehensively understand and interpret the details of human behavior by examining it from various perspectives. Stake (2010) characterized triangulation as a process to gather evidence from diverse individuals, types of data, or methods of data collection to support findings. Triangulation serves to improve the legitimacy of a study by examining a situation from multiple viewpoints (Stake, 2010). In this qualitative research, data triangulation is accomplished by gathering responses from participants through open-ended interviews and by using member checking to prove the accuracy of the data. The triangulation approach can minimize any biases and enhance the reliability of the data (Bogdan & Biklen, 2006). In this research, triangulation will be achieved through the use of diverse data sources, interviews, document analysis, observations, and field notes. The semi-structured interviews will include open-ended questions related to secondary teachers' and students' perceptions regarding STEAM education and integration. This research aims to provide a comprehensive understanding and analysis of STEAM education's potential.

4.2.1 Triangulation

Triangulation methodology was chosen for this research as a deliberate strategy to navigate the intricate landscape of the research objectives. This section delves into the nuanced reasoning behind selecting triangulation as the preferred methodological framework, offering a detailed exploration of its relevance, distinctions, and suitability within the research context. The decision to adopt the triangulation methodology rests on its ability to address the inherent complexity of the

research questions comprehensively by integrating multiple data sources, methods, and perspectives. This approach not only mitigates potential biases and limitations associated with singular methods but also enriches the depth and breadth of the study findings. Acknowledging the subjectivity of reality and the diversity of interpretations, triangulation embraces a pluralistic approach to data collection and analysis. By triangulating data from varied sources, the research aims to capture the multifaceted nature of the research topic, encompassing both objective observations and subjective experiences. This inclusive methodology facilitates a more nuanced understanding of the research phenomenon and seeks to enhance the credibility and trustworthiness of its findings. Triangulation ensures that the study outcomes withstand scrutiny and contribute meaningfully to scholarly discourse. In summary, the decision to employ triangulation methodology in this research emanates from a nuanced understanding of its relevance, advantages, and applicability within the research context. Triangulation offers a robust framework for navigating the complexities of the research questions and displaying multiple perspectives to yield rich and multifaceted insights. The research embraced triangulation to advance scholarly inquiry and generate knowledge that is both rigorous and impactful within the field.

4.2.2 Interviews

Interviews serve as a valuable tool for researchers to compare data displaying the central themes and notions from the participants. In qualitative research, interviews are designed to delve into the deeper meaning behind participants' experiences (Yin, 2014). Additionally, interviews hold a paramount position in qualitative research, as they empower researchers to delve into individuals' perspectives, experiences, understandings, meanings, interpretations, and perceptions of reality. In the realm of educational research, three primary interview formats are commonly employed: fully structured, semi-structured, and unstructured (Cohen et al., 2007; Mertens, 2010; Robson &

McCartan, 2016). A semi-structured interview follows a predefined guide encompassing specific topics, default phrasing, and sequence while remaining adaptable to the introduction of spontaneous questions. This approach facilitates the systematic collection of comprehensive data while retaining the conversational and context-driven nature of the interview (Cohen et al., 2007). The interviews in this research are influential in eliciting the perspectives and opinions behind participants' experiences in the context of implementing STEAM and its importance in education. Most of the interviews were conducted in person at the participants' respective schools and online if it was more convenient for the participants. Each interview was either audio recorded or transcribed directly and afterward coded for analysis. The interview questions were designed to obtain participants' perceptions regarding the integration and implementation of STEAM education in secondary classrooms. The preliminary questions centered around whether participants heard the term STEAM and what they knew about STEAM education. Subsequent questions related to the participants' reflection and perception regarding STEAM, their experiences, advantages, challenges, and STEAM integration's impact on students' learning. The open-ended questions used during the interviews are provided in Appendix B for reference. In the pursuit of my Ph.D. research objectives, the semi-structured interview methodology was selected due to its capacity for fostering in-depth discussions on quality and encouraging personal insights from various participants including students, teachers, and principals within the chosen institutions. This approach was deemed appropriate as it enables direct communication and allows interviewees to express their opinions and values authentically. The relationship between interviewer and interviewee, as theorized by scholars like Pierre Bourdieu, Alain Accardon, and Susan Emanuel (1999), is foundational to this method and relies on trust and rapport. The primary objective of the interviews is to elicit knowledge regarding participants' perspectives and experiences within a specific context, thus supporting a scientific understanding of social phenomena. This approach, as

discussed by scholars such as Brinkmann (2018) and Kvale & Brinkmann (2015), seeks to uncover the meanings rooted in individuals' experiences and interactions within a given social context. The semi-structured nature of the interviews allows for flexibility and aims to capture the diverse perspectives of the participants, concerning STEAM education in secondary schools in Hungary and Palestine. Interview planning is crucial in achieving research objectives by constructing a comprehensive interview script serving as a guide. This script assists in framing related questions and ensures alignment with the research focus. As highlighted by Ferreira (2014), interviews represent intersubjective constructions shaped by the interaction between interviewer and interviewee. Despite all the advantages of semi-structured interviews, challenges may arise, such as maintaining focus, managing silence, avoiding judgment, and upholding ethical standards, as outlined by Adams (2010). In summary, the semi-structured interview methodology offers a nuanced approach, deeper understanding, and exploration of the participants' perspectives and experiences. This method allows for rich and meaningful data collection essential for advancing scholarly inquiry.

4.2.3 Activity and Observation

STEAM activities integrate multiple disciplines allowing learners to make connections between different subjects and promoting a well-rounded approach to education. STEAM activities involve hands-on application, problem-solving, engagement, and collaboration among students. STEAM activities can develop critical thinking, creativity, and innovation, and many of these activities are experimental and realistic where participants learn by doing. This approach is effective because it makes learning more engaging and sparks curiosity, and an exploration to understand the world. Hence, STEAM activities portray a practical application of academic concepts and let learners see real-world applications. Through these activities, individuals can

express themselves and appreciate diverse perspectives. In summary, STEAM activities provide practical approaches to education developing learners' skills and abilities to prepare them for successful educational journeys and future careers. Gorman and Clayton (2005) portray observation studies as systematically recording observable phenomena or behavior in a natural environment. Some scholars embed observation within the broader framework of ethnography, while others narrow it down to participant observation. Spradley (1980) suggests that participation observation leads to ethnographic description and portrays ethnography as the task of illustrating a culture with the primary goal of understanding it from the native perspective. Chatman (1992) describes ethnography as a method of enabling researchers to gain an insider's view through observing in social settings. Becker and Geer (1970) define participant observation as an activity where the observer engages in the daily life of the subjects, observing events, listening to conversations, and interacting with people over an extended period. Participant observation is a valuable method for gaining insight into participants' perspectives by actively engaging in their activities. This type of method can be triangulated when obtaining the findings from one source or through a different data collection method. Additionally, observations help researchers understand participants' nonverbal expressions and social interactions. During the STEAM activity observations, the researcher will record observations by hand to capture behaviors, movements, tone, and verbal and nonverbal expressions that could provide further insight into the research process. Field notes taken during observations serve as a record of what was observed that aids in remembering certain details later (Merriam, 2002). Researchers employ field notes to thoroughly document nonverbal cues, settings, participant behaviors, and other interactions. These notes are used to interpret participants' perspectives and meanings (Yin, 2014). Additionally, field notes must be rich in description to capture the subtleties. These notes were used to record reflective insights during and after the STEAM activities which followed nonverbal and verbal signals, the physical

environment, and participant engagement. The analysis of field notes helped identify any emergent themes and then served for later coding and analysis. Field notes offer a chance to gather additional data and allow the researcher to document and reflect upon observations, thoughts, and experiences related to the research setting and activities. Yin (2009) advocates that field notes serve as essential tools for conducting case studies and enhance the reliability of the research. To minimize bias, the researcher asked the teachers during the STEAM activity to fill out an observation sheet regarding students' participation and engagement for the research to be more credible. The observation sheet can be found in Appendix 7 for reference.

4.2.4 Participant Observation

Allen (2017) explains participant observation as the process of entering a group of people with a shared identity to gain an understanding of their community. This process includes gaining knowledge and a deeper understanding of the participants, interactions, and events that take place at the research site. Researchers can gain an understanding of the group once they spend time with a group of people and closely monitor their actions, speech patterns, and norms. Participant observation, allows the researcher to seek out information through the researcher's direct participation and observation in the activities of the group being studied. Erlandson, Harris, Skipper, and Allen (1993) view participant observation as a method of collecting data that enables the researcher to describe existing situations using the five senses, furthermore, DeMunck and Sobo (1998) describe participant observation as the primary method used by anthropologists doing fieldwork. Fieldwork involves when the researcher is actively looking and writing detailed field notes (DeWalt & Dewalt, 2002). Nweke and Nwoba as described in Okolie and Ajene (2019), explain how participant observation serves as a method of gathering data, an approach for inquiry, and an essential element of qualitative research. Additionally, Allen (2017) describes participant

observation as immersing oneself within a group and sharing a common identity to comprehend their community dynamic, which entails acquiring in-depth insights into the individuals, interactions, settings, and occurrences. Lastly, Erlandson et al. (1993) view participant observation as a means to collect sensory-rich data, offering a vivid portrayal of the studied situation. Sanghera (2001) explains six factors researchers need to take into consideration during the research process- time, place, social circumstances, language, familiarity, and social consensus. These factors serve as guiding principles for structuring research efforts and facilitating a systematic approach to document the researcher's methodology and achieve meaningful results.

4.3 Participants

In qualitative research, sample size varies depending on the study's nature (Patton, 2002). McNamara (2009) noted that there is no set sample size for qualitative studies due to the extensive data generated and the complexity of the analysis. Similarly, Patton (2002) stressed that the credibility of qualitative research relies more on the richness of information gathered than on sample size. The participants in this research consisted of secondary teachers and students from two Hungarian and three Palestinian secondary schools. The sample size for this research comprised 23 secondary teachers, one from each grade level, selected from the target schools for the interviews. For anonymity, teachers have been assigned to numbers and their nationality for instance: Hungarian Teacher- HU Teacher 1 or Palestinian Teacher- PA Teacher 13, and so forth. The sample size for the secondary students, for the interviews, comprised 23, one from each grade level and the targeted schools, students as well were labeled the same as teachers for anonymity based on their nationality and assigned number, for instance, Hungarian Student- HU Student 1, Palestinian Student- PA Student 13, and so on. Lastly, 496 students, between grade levels 9^{th}-12^{th},

took part in a STEAM activity and observations for the research. The tables below display the participants who contributed to the research to obtain the research objectives.

Participants	Grade Level	Gender	Years of Teaching experience
Hungarian Principal 1	Principal	Female	15+
Hungarian Teacher 2	9th Grade Math	Female	5+
Hungarian Teacher 3	10th Grade Science	Male	10+
Hungarian Teacher 4	11th Grade Physics	Male	10+
Hungarian Teacher 5	10th Grade Math	Female	5+
Hungarian Teacher 6	9th Grade Science	Female	5+
Hungarian Teacher 7	9-12th Grade Art	Male	5+
Hungarian Teacher 8	11th Grade Science	Male	10+
Hungarian Teacher 9	10th Grade Math	Male	10+
Hungarian Teacher 10	12th Grade Math	Male	10+
Hungarian Teacher 11	10th Grade Science	Female	5+
Palestinian Principal 12	Principal	Female	15+
Palestinian Teacher 13	9th Grade Science	Female	5+
Palestinian Teacher 14	10th Grade Math	Female	10+
Palestinian Teacher 15	10th Grade Science	Male	10+
Palestinian Teacher 16	12th Grade Science	Male	10+
Palestinian Teacher 17	11th Grade Math	Male	10+
Palestinian Teacher 18	9th Grade Science	Male	10+
Palestinian Teacher 19	10th Grade Math	Female	5+
Palestinian Teacher 20	10th Grade Science	Female	5+
Palestinian Teacher 21	11th Grade Math	Female	10+
Palestinian Teacher 22	12th Grade Science	Female	10+
Palestinian Teacher 23	9th Grade Math	Female	5+

Table 4: Description of Teacher Participants (Interviews)

Participants	Grade Level	Gender	Age
Hungarian Student 1	10th Grade	Female	16
Hungarian Student 2	9th Grade	Female	15
Hungarian Student 3	11th Grade	Male	17
Hungarian Student 4	12th Grade	Female	18
Hungarian Student 5	9th Grade	Male	15
Hungarian Student 6	9th Grade	Female	15
Hungarian Student 7	11th Grade	Female	17
Hungarian Student 8	12th Grade	Female	19
Hungarian Student 9	10th Grade	Male	16
Hungarian Student 10	11th Grade	Female	17
Palestinian Student 11	9th Grade	Female	15
Palestinian Student 12	11th Grade	Female	17
Palestinian Student 13	10th Grade	Female	16
Palestinian Student 14	12th Grade	Female	18
Palestinian Student 15	11th Grade	Female	17
Palestinian Student 16	10th Grade	Male	16
Palestinian Student 17	9th Grade	Male	15
Palestinian Student 18	9th Grade	Female	15
Palestinian Student 19	12th Grade	Female	18
Palestinian Student 20	10th Grade	Female	16
Palestinian Student 21	11th Grade	Female	17

Palestinian Student 22	9th Grade	Male	15
Palestinian Student 23	12th Grade	Male	17

Table 5: Description of Student Participants (Interviews)

Participants	Grade Level	Nationality	School
16	9th Grade	Hungarian	School 1
14	10th Grade	Hungarian	School 1
17	11th Grade	Hungarian	School 1
15	12th Grade	Hungarian	School 1
12	9th Grade	Hungarian	School 2
20	10th Grade	Hungarian	School 2
26	11th Grade	Hungarian	School 2
25	12th Grade	Hungarian	School 2
20	9th Grade B	Hungarian	School 2
24	10th Grade B	Hungarian	School 2
27	11th Grade B	Hungarian	School 2
24	12th Grade B	Hungarian	School 2
17	9th Grade	Palestinian	School 1
16	10th Grade	Palestinian	School 1
16	11th Grade	Palestinian	School 1
15	12th Grade	Palestinian	School 1
28	9th Grade	Palestinian	School 2
28	10th Grade	Palestinian	School 2
15	11th Grade	Palestinian	School 2
22	12th Grade	Palestinian	School 3
16	9th Grade	Palestinian	School 3
17	10th Grade	Palestinian	School 3
22	11th Grade	Palestinian	School 3
23	12th Grade	Palestinian	School 3

Table 6: Description of Student Participants- STEAM Activity and Observations

4.4 Data Collection

Before data collection, approvals were obtained from the research institutions with permission from the school principal. The researcher contacted one of the teachers of each school to assist with conducting the STEAM activity in a science and math class between the grade levels of 9th and 12th. The researcher gave the designated math or science teacher for their respective grade level the information letter and consent forms to partake in the STEAM activity for their parents to sign if the student is under 18 years of age. When the researcher obtained all the consent forms, the STEAM activity was conducted with the respective teacher present in the classroom to assist with observational notes.

4.4.1 STEAM Activity and Observation

I researched and prepared two STEAM activities that seemed suitable for secondary school students for a math and science class, where I explored different STEAM activities on the internet. After researching and investigating the appropriate STEAM activities, I began to reflect on what the objectives are and the possible outcomes when students participate in the STEAM activities. I decided to create two PowerPoints, one for each activity, by giving a brief introduction to the math or science lesson and the instructions for the STEAM activity. Additionally, I created an observation sheet for the teachers aiding me during the activity. In this observation sheet, the teachers will write the description of the STEAM activity, what the participants were doing during the STEAM activity by specifying certain behaviors or interactions, and what methods were used (see Appendix 7). During the STEAM activity, I, the researcher, observed and recorded how the students were engaging and interacting with one another during the activity. I was writing field notes that served as a written log of immediate observations and emerging themes. I watched, audio recorded, and documented the students' participation during the STEAM activity, noting particular actions, interactions, or reactions. I took detailed field notes while my fellow teacher filled out the observation sheet to capture qualitative aspects, such as student conversations, expressions, and collaboration. We intentionally positioned ourselves within the classroom to have an encompassing and clear view of the students. I walked around the groups, stopping to audio-record and take notes, and choosing optimal vantage points to observe multiple students simultaneously allowing for a more comprehensive understanding of the collective experience. Qualitative data, including observations, interviews, and field notes, can be analyzed thematically. After the completion of the activity, I collected the teachers' observation sheets and with my filed notes I identified recurring themes, patterns, and meaningful concepts that emerged from the data and provided a

comprehensive understanding of the qualitative aspects of the STEAM activity. These qualitative measures collectively contribute to a holistic understanding of the STEAM activity and highlight the participants' experiences and perspectives. Through this qualitative approach, I gained valuable insights into the intricate dynamics of art-based methods within the interdisciplinary context of STEAM education. I also employed the constant comparative method by continually comparing new observations with existing codes and themes to refine and deepen the analysis. Lastly, throughout the observation process, I engaged in reflexivity by acknowledging my role as an outsider and how my presence may influenced the participants' engagement and reaction to the activity. This self-awareness is crucial for mitigating biases and enhancing credibility. I collected nuanced qualitative data from note-taking, strategic observation, and the observation sheets where the data displayed a comprehensive understanding of the participants' experiences, emotions, and interactions during the STEAM activity. Furthermore, to enrich the dataset and enhance the validity of the findings, the observation sheet was dispersed to the classroom teacher, who provided additional insights and observations based on their pedagogical expertise and intimate knowledge of the student's capabilities and tendencies. The completed observation sheets were subsequently collected, collated, and subjected to qualitative analysis to discern emergent themes, patterns, and discrepancies in students' engagement with the STEAM activity. This methodological framework facilitated a holistic and nuanced understanding of the multifaceted dimensions of student participation in STEAM learning experiences, thereby enriching the empirical basis for subsequent interpretations and conclusions within the broader context of the doctoral thesis.

4.4.2.Semi- structured Interviews

The researcher was assisted with a list of math and science teachers who were interested in partaking in the interview portion of this research. When the teachers agreed to the interview they

signed the Participant Consent Form (refer to Appendix 2-4) and the information letter and format of the interview were given to each participant. Individual semi-structured interviews were conducted at times and locations convenient for each participant. All interviews were recorded and conducted in a confidential and secluded manner, with only the interviewee and researcher present. Interviews were chosen as an optimal method for gathering data on perspectives, experiences, and personal narratives (Yin, 2014). The semi-structured interviews consisted of open-ended questions aimed at obtaining teachers' perceptions of STEAM education (refer to Appendix 8). Each semi-structured interview lasted approximately 30-45 minutes. Regarding the students' interviews, the researcher asked the students if they were willing to participate, and if so they were given a Participant Consent Form to obtain permission from their parents if under 18 years of age. When the forms were collected, the interview was conducted at their respective schools with a teacher present and the interviews lasted around 20-25 minutes. The semi-structured interviews contained open-ended questions designed to acquire students' perceptions of STEAM education (refer to Appendix 8). Each semi-structured interview consisted of twelve questions posed to each participant (refer to Appendix 8). The interviews were conducted in English, recorded, and later transcribed for data analysis. All interviews were recorded for accuracy and replayed to ensure precise transcription. Each transcript underwent a thorough review by the researcher at least three times to guarantee accuracy. Research notes were carefully maintained by the researcher to capture relevant gestures, sounds, or noteworthy occurrences during interviews that may not have been captured by audio recordings. The researcher engaged in bracketing by setting aside all preconceptions (Merriam, 2002). The researcher independently analyzed the transcripts which involved a thorough reading and re-reading of field notes and transcripts to ensure accuracy and identify significant statements and meanings. The researcher used a qualitative software planned to highlight and group coded words around meaningful thoughts or ideas in the data, known as

categorization. The objective is to discern patterns, themes, and meanings from interviewees' statements and phrases. Lastly, the researcher reflected on what was transcribed about STEAM education to see if the participants' perceptions supported the main problem statement of the research.

4.4.3 Thematic Analysis

The research applies a thematic analysis and follows the methodologies brought forth by Merriam (2002). The researcher possessed the ability to empathize with the participants' lived experiences and essentially captured the relevance of their shared perceptions supplementing the thematic analysis (Shank, 2006). Merriam (2002) describes coding as a process of questioning, comparing, and drawing conclusions from the data to gain new insights. The analysis process involves transcribing the recorded interviews, coding the data, classifying the coded data, and lastly recognizing similar patterns and themes. The analysis began with the STEAM activities and observation, subsequently, the researcher will employ the constant comparative method to code and record data until emerging themes become apparent. The constant comparative method entails breaking down the data into meaningful units and coding them into categories (Glaser, 1965). Additionally, documentation and field notes were used to reinforce themes that were applicable throughout the analysis process. The coding process began with open coding involving repeated readings to identify concepts and categories regarding perceptions of STEAM which generated numerous codes. These codes were subsequently organized into categories. The themes were compared with the themes from the research notes and cross-checked against coded citations and the entire dataset. A comprehensive review of the data was conducted to identify any additional themes. The researcher iteratively read and re-read the data to continually identify themes until no further themes emerged. The coding process was guided by the framework and procedures

proposed by Miles et al. (2014) and involved two primary phases: the initial coding phase (first cycle) and the subsequent pattern coding phase (second cycle). To begin, the researcher conducted the initial coding phase, where data from interviews was systematically dissected into distinct components. These components were then closely examined and compared to identify commonalities and differences between teachers and students from Hungary and Palestine. This initial coding phase employed two distinct methods: descriptive coding, which entailed assigning concise labels to encapsulate the essence of data segments, and using MAXQDA, which directly employed participants' own words and phrases from the data. The subsequent pattern coding (second cycle) was carried out to condense these summaries into a smaller number of categories and themes. Throughout the entire coding process, the researcher maintained analytic memos, as advocated by Saldana (2013). These memos served as documentation of the evolving coding process, prompting deeper reflections by the researcher on the significance of the data. They constituted a transitional phase bridging the gap between coding and the subsequent reporting of the study's findings. The data was stored, secured, and protected on the researcher's laptop with a protected password. Each participant had a folder labeled with a number and nationality to distinguish between the participants and maintain participant confidentiality. Original paper documents such as the researcher's field notes and the teacher's observational sheet were stored in a locked file drawer at the researcher's home and were then scanned to have a digital copy and secured in a protected password folder. The final stage was data verification which involved checking the legitimacy of the data by reviewing the transcripts and codes to prove the problem statement (Sarantakos, 1998).

4.4.4 Ethical Considerations

I submitted a research proposal to my faculty, who granted ethical approval before commencing data collection at the Hungarian schools. Regarding the Palestinian schools, I contacted the schools directly with the information letter about my research regarding the data I will collect, and consent forms. Throughout the research process, I remained conscientious about the potential impact on participants and society as a whole, ensuring appropriate conduct. Kumar (2005) emphasizes the unethical nature of collecting information without participants' knowledge, willingness, and informed consent. Hence, I informed all participants that their involvement was voluntary, and they had the liberty to withdraw from the study at any time. In the course of the study, informed consent was obtained from all participants, who were also assured that they were not obligated to answer any of my questions that made them uncomfortable. Participants received advance notice of the interviews, an overview of the discussion topic, the type of information sought, the research's purpose, and how their provided information would be used. Before each interview, participants were informed about the expected interview duration, and ample time was allocated for them to ask any questions related to the research topic. All participants signed a consent form, indicating their willingness to participate while ensuring confidentiality and anonymity throughout the process. The information letter and consent forms are seen in Appendix 1-5 for reference. Participants were anonymized as Hungarian Teacher/Student (HT#1/HS#2) Palestinian Teacher/Student (PT#14/PT15), and so forth. The research excluded any identifying details such as their name, age, or school affiliation. Furthermore, given my role as an insider in the research, measures such as the school teachers were employed to mitigate the potential influence of insider status on data analysis and interpretation. I made sure to be mindful of the participants and just focused on questions about the topic and I established a rapport with the participants to encourage candid and transparent responses (Merriam, 2002).

4.5 Limitations and Conclusion

The research design of this study exhibited several limitations. Firstly, the sample size for the interview portion may have been insufficient to fully capture the significance of STEAM within the data, thereby deterring the ability to generalize findings to a wider population. Thus, the limited number of interviews conducted might not accurately reflect the diverse viewpoints and beliefs held by all teachers and students in Hungary and Palestine regarding the significance of incorporating STEAM education. Another notable limitation is the impact of COVID-19, which likely affected the research process and outcomes. The global pandemic disrupted traditional educational practices, shifting many teaching and learning activities to remote or hybrid formats. This change in the educational landscape could have influenced the perspectives and experiences of educators regarding STEAM integration. Furthermore, the absence of Canadian participants and secondary schools in the research sample presents a limitation in terms of the geographical scope and diversity of perspectives represented. Canada displays a rich educational landscape and diverse cultural contexts that could have offered valuable insights into STEAM integration practices. Therefore, the absence of Canadian participants diminishes the comprehensiveness and scale of the research findings.

This chapter has provided a detailed overview of the research design and methods employed in this thesis. The research design was carefully crafted to address the central research questions regarding STEAM education. The research applied a qualitative approach using qualitative methods such as interviews, document analysis, STEAM activities, and observations. This demonstrated a nuanced exploration of the participants' perspectives regarding the research topic., Despite the mentioned limitations, the chosen methods and design can offer valuable insights into

the complexities of STEAM education and set the base for the following analysis and discussion chapters.

5. Data Analysis and Results

5.1 Introduction

The main point of this investigation is centered on the perceptions of educators, administrators, and students regarding the integration of STEAM in a secondary educational setting in Hungary and Palestine. The researcher aimed to deepen their understanding of how STEAM education is being put into practice at the secondary level. Data collection for this research entailed STEAM activities, observation, field notes, and semi-structured interviews. The thesis aimed to fill a research void concerning the necessity and support for implementing STEAM in secondary schools in Hungary and Palestine. STEAM education bridges students' learning experiences with their life experiences or cultural backgrounds, as highlighted by Hammond and Jackson (2015). Teachers' instructional approaches are also influenced by their cultural perspectives which impact students' learning outcomes. The research followed Yin's (2014) methodology of data triangulation and validating the research outcomes from various sources. This triangulation involved comparing and verifying findings from teacher, administrator, and student interviews, and observation notes to determine consistent conclusions.

Chapter 5 is structured into seven sections, each serving a distinct purpose. These sections include the Participant Sample, STEAM activity and observation, Summary of the Findings, Participant Sample, teachers and students interviews, Summary of the Findings, and Chapter Summary. Firstly, the participant sample section provides a description of the research's participants and an overview of the demographics and characteristics of the participants. The Data and Results sections present the collected data and the results of the analysis in an organized manner to demonstrate a clear understanding of the study outcomes. The Summary of Findings Section portrays the key themes derived from the coding process from the information gathered

from the STEAM activity, observations, and semi-structured interviews. The section also illustrates an overview of the major findings obtained from the analysis. The last section, Chapter Summary, summarizes the main points that occurred from the study findings.

5.2 Participant Sample

Secondary schools were the main sample for this research to emphasize the lack of arts in education. The researcher contacted, via email, various schools in Hungary and Palestine. The introduction emails entailed the information letter regarding the research, an introduction of the researcher, and a description of the data collection. Upon agreement with two Hungarian and three Palestinian schools, the researcher met with a fellow teacher from each school to assist with coordinating the dates and times to conduct the STEAM activities and interviews. The researcher reached out personally to teachers and students to partake in an interview. Four-hundred ninety-six students participated in the STEAM activities. Every individual before the STEAM activity was given a consent form to sign and return to the researcher. Qualitative data was collected from the STEAM activities and observations administered between the dates of October 2021 and March 2023.

5.3 STEAM Activity and Observations

5.3.1 Green City Activity

This STEAM activity that was conducted in the 11th and 12th-grade classrooms involved the subjects of science and engineering. The name of the STEAM activity is “Green City”, in this activity, students were put into groups of 3 or 4 depending on the size of the students in the class, and where they were given A3 paper or a poster to create their version of a green or eco-friendly city. Before dividing the students, the researcher gave a brief and short PowerPoint of what is a

green city and some aspects of what makes a green city environmentally friendly by using photos and infographics. After the short presentation, students began creating their green city, which took about 30-45 minutes, depending again on the class time the school had assigned. Lastly, the students presented their green city to the rest of the class which lasted about 10 minutes total. The project samples from this activity can be found in Appendix 9.

Participants	Context	Environment	Summary
Palestinian School #1- 11th Grade Science Class (16 Students)	Topic: Green/Eco-friendly City Duration: 45’	Seating Arrangement: Students have their desks	First, the students were given a 10’ PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their green city. Students had to move around their desks in the classroom. The researcher began observing the groups’ activity and engagement. Later, each group presented their green city to the class.
Palestinian School #1- 12th Grade Science Class (15 Students)	Topic: Green/Eco-friendly City Duration: 45’	Seating Arrangement: Students have their desks	First, the students were given a 10’ PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 3 and were given A3 papers to create their green city. Students had to move around their desks in the classroom. The researcher began observing the groups’ activity and engagement. Later, each group presented their green city to the class.
Palestinian School #2- 11th Grade Science Class (15 Students)	Topic: Green/Eco-friendly City Duration: 50’	Seating Arrangement: Students have their desks, but are paired together	First, the students were given a 15’ PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 3 and were given A3 papers to create their green city. Students had to move around the classroom to their groups. The researcher began observing the groups’ activity and engagement. Later, each group presented their green city to the class.
Palestinian School #2- 12th Grade Science Class (22 Students)	Topic: Green/Eco-friendly City Duration: 50’	Seating Arrangement: Student pairs are seated in a two-person desk	First, the students were given a 15’ PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 3-4 and were given A3 papers to create their green city. Students had to move around the classroom to get to their groups. The researcher began observing the

			groups' activity and engagement. Later, each group presented their green city to the class.
Palestinian School #3- 11th Grade Science Class (22 Students)	Topic: Green/Eco-friendly City Duration: 45'	Seating Arrangement: Students have their desks	First, the students were given a 10' PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 3-4 and were given A3 papers to create their green city. Students had to move around their desks in the classroom. The researcher began observing the groups' activity and engagement. Later, each group presented their green city to the class.
Palestinian School #3- 12th Grade Science Class (23 Students)	Topic: Green/Eco-friendly City Duration: 45'	Seating Arrangement: Students have their desks	First, the students were given a 10' PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 3 and were given A3 papers to create their green city. Students had to move around their desks in the classroom. The researcher began observing the groups' activity and engagement. Later, each group presented their green city to the class.
Hungarian School #1- 11th Grade Science Class (17 Students)	Topic: Green/Eco-friendly City Duration: 45'	Seating Arrangement: Students are seated in pairs	First, the students were given a 10' PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 3-4 and were given A3 papers to create their green city. Students had to move around in the classroom to get into a group. The researcher began observing the groups' activity and engagement. Later, each group presented their green city to the class.
Hungarian School #1- 12th Grade Science Class (15 Students)	Topic: Green/Eco-friendly City Duration: 45'	Seating Arrangement: Students are seated in pairs	First, the students were given a 10' PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 3 and were given A3 papers to create their green city. Students had to move around to get to their group. The researcher began observing the groups' activity and engagement. Later, each group presented their green city to the class.
Hungarian School #2- 11th Grade A Science Class (26 students)	Topic: Green/Eco-friendly City Duration: 60'	Seating Arrangement: Students are seated in groups around a table	First, the students were given a 15' PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4-5 and were given white posters to create their green city. Students didn't have to move because they were already seated in a group upon entering the classroom. The researcher began observing the

			groups' activity and engagement. Later, each group presented their green city to the class.
Hungarian School #2- 11th Grade B Science Class (27 Students)	Topic: Green/Eco-friendly City Duration: 60'	Seating Arrangement: Students are seated next to each other in three rows in the classroom	First, the students were given a 15' PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4-5 and were given white posters to create their green city. Students didn't have to move because they were already seated in groups in a row upon entering the classroom. The researcher began observing the groups' activity and engagement. Later, each group presented their green city to the class.
Hungarian School #2- 12th Grade A Science Class (25 Students)	Topic: Green/Eco-friendly City Duration: 60'	Seating Arrangement: Students are seated in groups around a table	First, the students were given a 15' PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4-5 and were given white posters to create their green city. Students didn't have to move because they were already seated in a group upon entering the classroom. The researcher began observing the groups' activity and engagement. Later, each group presented their green city to the class.
Hungarian School #2- 12th Grade B Science Class (24 Students)	Topic: Green/Eco-friendly City Duration: 60'	Seating Arrangement: Students are seated in groups around a table	First, the students were given a 15' PowerPoint presentation from the researcher about the topic of a green and environmentally friendly city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4-5 and were given white posters to create their green city. Students didn't have to move because they were already seated in a group upon entering the classroom. The researcher began observing the groups' activity and engagement. Later, each group presented their green city to the class.

Table 7: Participants of the Green City STEAM Activity and Summary

5.3.2 Geometric City Activity

This STEAM activity was conducted in the 9th and 10th grade classrooms involving the subject of mathematics. The name of the STEAM activity is "Geometric City", in this activity, students were put into groups of 3 or 4 depending on the size of the students in the class, and where they were given A3 paper or a poster to create their geometric city. Before dividing the students, the researcher gave a brief and short PowerPoint on a simple lesson about basic geometry and some

examples of geometric cities by using photos and infographics. After the short presentation, students began creating their geometric city, which took about 45 or 60 minutes, depending on the class time the school had assigned for their math class. Lastly, the students presented their geometric city to the rest of the class which lasted about 10 minutes total. The project samples from this activity can be found in Appendix 10.

Participants	Context	Environment	Summary
Palestinian School #1- 9th Grade Math Class (17 Students)	Topic: Geometric City Duration: 45’	Seating Arrangement: Students have their desks	First, the students were given a 10’ PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher began observing the groups’ activity and engagement. Later, each group presented their geometric city to the class.
Palestinian School #1- 10th Grade Math Class (16 Students)	Topic: Geometric City Duration: 45’	Seating Arrangement: Students have their desks	First, the students were given a 10’ PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher began observing the groups’ activity and engagement. Later, each group presented their geometric city to the class.
Palestinian School #2- 9th Grade Math Class (28 Students)	Topic: Geometric City Duration: 50’	Seating Arrangement: Students have their desks, but are paired together	First, the students were given a 10’ PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher began observing the groups’ activity and engagement. Later, each group presented their geometric city to the class.
Palestinian School #2- 10th Grade Math Class (28 Students)	Topic: Geometric City Duration: 50’	Seating Arrangement: Student pairs are seated in a two-person desk	First, the students were given a 10’ PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher began observing the groups’ activity and

			engagement. Later, each group presented their geometric city to the class.
Palestinian School #3- 9th Grade Math Class (16 Students)	Topic: Geometric City Duration: 45’	Seating Arrangement: Students have their desks	First, the students were given a 10’ PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher began observing the groups’ activity and engagement. Later, each group presented their geometric city to the class.
Palestinian School #3- 10th Grade Math Class (17 Students)	Topic: Geometric City Duration: 45’	Seating Arrangement: Students have their desks	First, the students were given a 10’ PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher began observing the groups’ activity and engagement. Later, each group presented their geometric city to the class.
Hungarian School #1- 9th Grade Math Class (16 Students)	Topic: Geometric City Duration: 45’	Seating Arrangement: Students are seated in pairs	First, the students were given a 10’ PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher began observing the groups’ activity and engagement. Later, each group presented their geometric city to the class.
Hungarian School #1- 10th Grade Math Class (14 Students)	Topic: Geometric City Duration: 45’	Seating Arrangement: Students are seated in pairs	First, the students were given a 10’ PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher began observing the groups’ activity and engagement. Later, each group presented their geometric city to the class.
Hungarian School #2- 9th Grade B Math Class (12 students)	Topic: Geometric City Duration: 60’	Seating Arrangement: Students are seated in groups around a table	First, the students were given a 10’ PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher

			began observing the groups' activity and engagement. Later, each group presented their geometric city to the class.
Hungarian School #2- 10th Grade Math Class (20 Students)	Topic: Geometric City Duration: 60'	Seating Arrangement: Students are seated next to each other in three rows in the classroom	First, the students were given a 10' PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher began observing the groups' activity and engagement. Later, each group presented their geometric city to the class.
Hungarian School #2- 9th Grade A Math Class (20 Students)	Topic: Geometric City Duration: 60'	Seating Arrangement: Students are seated in groups around a table	First, the students were given a 10' PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher began observing the groups' activity and engagement. Later, each group presented their geometric city to the class.
Hungarian School #2- 10th Grade B Math Class (24 Students)	Topic: Geometric City Duration: 60'	Seating Arrangement: Students are seated in groups around a table	First, the students were given a 10' PowerPoint presentation from the researcher on a quick and brief lesson on simple geometry rules and examples of a geometric city. After the presentation, the researcher explained the STEAM activity. Students were then put into groups of 4 and were given A3 papers to create their geometric city. Students had to move around their desks in the classroom. The researcher began observing the groups' activity and engagement. Later, each group presented their geometric city to the class.

Table 8: Participants of the Geometric City STEAM Activity and Summary

5.3.3 Data Collection

In this Ph.D. study, the observation method serves as a way to capture different insights into students' engagement and behaviors during STEAM activities. I thoroughly documented observations to reveal the diverse dynamics within the classroom environment. An observation sheet was provided to teachers allowing them to offer supplementary perspectives on student interactions and performances during these activities. Data collection commenced with the researcher's presence within the classroom setting, the researcher prepared a PowerPoint

presentation regarding the STEAM activity, the researcher gave a 10-15 minute presentation and explained the activity, and then students conducted the activity. The figure displays the process of conducting the STEAM activity in a math or science classroom.

I utilized a participatory observation approach and was actively immersed in the learning environment, keenly observing students' actions, interactions, and reactions to the activity at hand. Detailed field notes were diligently recorded by the researcher, and teachers recorded their observations by completing the observation sheet to collect qualitative data about student engagement levels, collaborative efforts, problem-solving strategies, and indicators of creativity and critical thinking. This instrument facilitated systematic data collection and enabled teachers to document appropriate and valuable observations regarding student behavior, academic performance, and social interactions throughout the activities. Two research questions were answered by conducting STEAM activities in secondary math and science classrooms.

RQ1: What are the key factors influencing the successful implementation of STEAM education programs in secondary math or science classrooms?

RQ2: How does STEAM learning impact students' learning experience, attitudes, interests, and academic achievement?

These research questions were answered during the activity and when the researcher coded the field notes and observation sheets into two thematic code groups, the positive advantages of STEAM activities, and the challenges of conducting a STEAM activity in a math or science lesson.

5.3.4 Results

The detailed findings from these observations are crucial for a complex exploration of the interdisciplinary learning environment. The themes that emerged from the observations and field notes from this activity are displayed in the table below.

Theme 1	Collaborative Decision Making
Theme 2	Dynamic Role-Shifting
Theme 3	Engagement
Theme 4	Creativity and Innovativeness
Theme 5	Positive Expressions/Emotions

Table 9: Summary of Observation and Field Notes

Several salient themes emerged from the observations conducted by both the researcher and teachers, shedding light on various facets of student engagement and performance during STEAM activities. Commencing with the first theme that occurred from observations and field notes was that students were immediately ready to work together. Students began having discussions on how they wanted to plan their city. Many groups are animated and lively about the activity. Observations revealed that decision-making was not dominated by a one-person discussion; but rather, a collective effort. Students actively participated in expressing their opinions and exchanging design aspects, having a united approach to the creative process. Small groups were formed organically, with students engaging in lively discussions about their artistic vision and how to incorporate scientific concepts into the collaborative activity. The initiation of collaborative discussions demonstrated a proactive approach to the interdisciplinary approach of the project. Throughout the activity, observations further revealed a balance between divergent and convergent thinking. During the beginning of the activity, students started with divergent thinking by brainstorming different ideas for the activity. As the project progressed, there was then a shift towards convergent thinking, where students collectively narrowed down their ideas to create a cohesive, unified, and creative depiction of their green city. Therefore, observations have indicated a willingness among the students to compromise for the collective benefit of the activity, depicting the ability for effective communication and solutions. The first observation that was automatically seen was collaboration. This theme was highly evident during the activity which revealed shared efforts among the group participants. Primarily, the formation of the collaborative groups was natural and

organic, highlighting students' natural inclination to work together. As they commenced the geometric art project, students gravitated toward one another and discussions about the activity flowed seamlessly. This initial grouping not only showcased the social dynamics within the classroom but also laid the base for the collaborative atmosphere that was portrayed throughout the entire activity. Within these groups, the researcher observed animated discussions and exchanges of ideas. Students actively engaged with one another, not only on the artistic factors of their city but also on the different geometric shapes and tools to use to create their city. This observation was taken a step further from just the collaboration aspect mentioned above. The discussions in the groups revealed a collective sense of exploration and problem-solving, as students directed the connection between art and math. This collaborative problem-solving was particularly evident when groups faced challenges in merging artistic creativity with mathematical accuracy when using specific tools to create geometric shapes. The observation further revealed a versatile approach to problem-solving, reflecting the students' capacity to adapt, think critically, and creatively address issues encountered during the activity. Initially, students grasped the task of trying to mix art into this geometry activity, by discussing different designs, what shapes to use, what places will be in their city, and how to be innovative. This creative problem-solving displayed the students' ability to pilot the differences between blending art and math. There were also instances where some groups restarted their activity by taking another paper to re-design or rec-create their city or making adjustments based on mathematical considerations emphasizing the application of problem-solving skills. This mirrored real-world problem-solving situations where adaptability and adjustment are essential. The observations underline the importance of cultivating adaptive thinking and collaboration which are crucial skills to their broader academic and professional development.

The next theme that emerged from analyzing the data was dynamic role-shifting. Throughout the activity, roles within the groups were also dynamic. Students were shifting between leadership roles from being active contributors to having supportive roles. The fluidity of roles ensured that each participant had opportunities for both individual expression and collaborative contribution. From this activity, students showcased the adaptability and flexibility of navigating the STEAM activity. The observation of dynamic roles within collaborative groups during the STEAM activity provided beneficial and valuable insights into the adaptability of student interactions. One aspect of the dynamic roles was the alternation of leadership within the collaborative groups. At different stages of the art activity, various students took on leadership roles, pushing them into making decisions about the activity and providing guidance to their teammates. Therefore, the STEAM activity allowed each student the opportunity to exercise leadership skills and provide their ideas and perspectives to succeed in their activity. This led the observer to view how most students were active contributors to the activity. Some students began taking the lead in proposing artistic ideas and explaining different scientific terms and concepts, other students were giving feedback, some with better artistic abilities took initiation in drawing or sketching, other students were communicating effectively with the group, and lastly, some students were giving positive encouragement to their teammates regarding the ideas about the activity. In conclusion, these observations portrayed how students were collaborating in their group to create a unique and thoughtful green city. Through this role-shifting student demonstrated different skill sets that contributed to the overall success of their STEAM activity. Some students had artistic skills in drawing, some students enjoyed coloring, and some students preferred sketching their city. It was important to view how each student used their strength in the group to complete the activity. Thus, recognizing students' preferred skills demonstrated an acknowledgment of individual strengths within the collaborative context, promoting an inclusive and well-rounded approach to the art

activity. The thorough field notes taken during each session of the collaborative STEAM activity further enriched the qualitative analysis, capturing the details of student engagement, innovativeness to the activity, and expressions. The following detailed notes and findings emerged from the observation. The observer wrote notes consistently during the activity process and documented high levels of engagement among the students. Regardless of perhaps never accomplishing or conducting a STEAM activity before, there was a profound enthusiasm and commitment to the activity especially during the collaborative process. Students' engagement created an atmosphere of collective creativity and shared learning. The diversity of artistic contributions was a striking feature noted in the observer's notes. Students embraced a range of creative expressions, experimenting with different colors, textures, and artistic techniques. From sketching representations to then creating detailed illustrations of their green city, therefore, the notes illuminated unique and contrasted styles from each participant which impacts the collaborative learning process. Many students portrayed the importance of innovation through their green city posters. Each group was different and illustrated innovative ways to make a green and eco-friendly city. Students brought forth different and unique concepts on how to promote a green city, which showcased a forward-thinking approach to the connection of art in science and engineering. Students' green cities illustrated a plethora of colors and different color schemes. Students wanted to color to demonstrate the different aspects of their green city. Vibrant and contrasting colors are usually used when there is a sense of excitement and enthusiasm, while some groups use subdued tones or just black and white which can portray a thoughtful and contemplative mood. The classroom setting presented a dynamic environment where students enthusiastically participated in the activity requiring them to visually interpret and represent mathematical principles through artistic means. The diverse range of artistic approaches employed by the students was markedly noteworthy. Some students chose to create intricate geometric patterns, while others

embraced abstract representations, demonstrating a range of artistic interpretations. There was a diversity of artistic styles observed that underscored the individuality and creativity of each student, revealing a variety of perspectives within the learning environment. This art-math integration not only deepened the students' comprehension of mathematical concepts but also explained the complex nature of artistic expression. More importantly, this activity strayed away from the conventional pedagogical methods where it encouraged students to explore mathematics through a personal and imaginative perspective leading to engagement within the classroom. Notably, the next observation displayed from the geometric cities was the utilization of a colorful palette. As students engaged in constructing geometric cities, the colorful spectrum of colors used to represent various mathematical elements was visually appealing. The careful consideration and intentional use of color in this context were indicative of a thoughtful integration of aesthetic choices with mathematical concepts. Students seamlessly incorporated shades and tones to portray geometric shapes, highlight patterns, and articulate spatial relationships within their city. The colorful palette served as a visual aid enhancing the precision of the mathematical concepts under consideration. This observation demonstrated how visual elements can boost and increase the understanding of geometric principles, making the learning experience more engaging and impactful for high school students. The exploration of color within the context of the geometric city activity provides useful awareness of the correlation between art and mathematics. This contributes to the bigger discourse on innovative interdisciplinary teaching approaches and methods. The next observation that stood out was precision and attention to detail when the students were creating their geometric cities. The students approached the task with a keen focus on accuracy, using and asking for rulers or protractors to ensure precise angles and dimensions in their geometric constructions. This detail to precision not only displayed a deep understanding of mathematical concepts but also portrayed the students' ability to interpret abstract notions into tangible and accurate visual representations.

Additionally, students added details and were comprehensive with their geometric cities by being committed to depicting an excellent city where they could add art to math concepts. This observation shows how art can be incorporated into a math class and how students appreciate, engage, create, and enjoyably understand math. Art in a mathematics class benefits interdisciplinary teaching methods, linking the gap between the worlds of art and mathematics in the high school curriculum.

The next observation that was displayed from the group STEAM activity was critical thinking skills. The observations revealed a multi-layered approach to critical thinking, encompassing analytical perceptions, evaluation of concepts, and the combination of information to create a cohesive and meaningful artistic project combined with mathematical notions. Analytical reasoning was significantly exhibited as students grappled with the task of incorporating geometric concepts into their artistic designs. When students were using mathematical principles it required a thorough and careful use of angles, symmetry, and precision within the creative process, thus some groups were using geometric tools to make their shapes as accurate as possible. This portrayed their capability to deconstruct abstract concepts and make them tangible and visually appealing. Students were observed assessing the effectiveness of their artistic choices about the geometric concepts. This ability demonstrated a high level of cognitive engagement and reflective thinking. Combining the information from what they know in geometry and art effortlessly was displayed during the activity. The mixture of art and math blended very easily through their city and conveyed a personal and creative interpretation. This reflected the students' capacity to connect and unify diverse knowledge domains.

The last theme that was displayed from the observations and field notes was students' positive expressions and emotions towards the STEAM activities. Verbal expressions were

captured in the field notes, revealing the language used by students to express their thoughts and reflections on the collaborative process during the STEAM activity. These phrases were mostly heard and written down by the observer, such as, “We decided to,” “We thought about it this way,” “Let's try this,” and “I think it looks better this way” were recurring. This depicted a shared sense of ownership and decision-making in the groups. In the Hungarian School 2+3, some students were discussing in Hungarian so the teacher that was in the class translated for me the common phrases that we recited from the students mentioned above. A sense of excitement and enthusiasm among the students was displayed and students were eager to explore the use of art in science, math, or engineering topics. Students were energetic and enthusiastic about the STEAM activity because they were ready to try something new and different in their science class. Students were excited about being creative and working in a group that could lead to a positive effect on their learning experience. The next emotion that was presented from the observational notes was pride when students were discussing their ideas among their group and when they presented their green city to the class. They also felt accomplished after completing their green city because they were able to create and produce their green city and how they thought it should look. Therefore, this portrays how art can benefit science and how interconnected they are. The collaborative posters served as a tangible representation of their combined efforts and creativeness. The subsequent expression that was noted was general curiosity and a genuine interest in exploring how art can be integrated into a science, math, or engineering lesson. Students were curious about learning new concepts and how one can be impacted by using art in a science class. Students were ready to delve into and explore this STEAM activity by connecting prior theoretical concepts with artistic creativity forming inventive posters. To sum up, the observations and field notes produced a comprehensive understanding of the student’s interactions during the collaborative STEAM activity. These findings contribute valuable insights into the expansive perspective of collaborative learning,

artistic expression, and social dynamics in a group activity. During the observation process, an array of facial expressions was flashed by the students during the activity. As students engaged in the creative process of constructing their geometric cities, their facial expressions mirrored a wide range of emotions and cognitive processes. Some students had expressions of deep concentration, furrowing their brows as they precisely measured and crafted different geometric shapes. Others have shown looks of satisfaction and accomplishment as they successfully translated abstract mathematical concepts into visually appealing cities. Students also displayed expressions of being thoughtful to their classmates regarding their ideas, and determination to complete their geometric cities. The variety of facial expressions uncovered the interaction between the cognitive engagement expected by the mathematical aspects of the task and the emotional responses prompted by the creative process. Thus, the observation of varied facial expressions in the geometric city activity shows that students were willing to engage in the activity, were motivated, and displayed enthusiasm towards the STEAM activity. As students engaged in the activity, their verbal communication displayed different tones and content. During the collaboration process, observations of students exchanging ideas and discussing creative choices about their geometric city. Some students verbalized their problem-solving strategies by explaining their thought processes, while others sought different explanations and methods through questions. Moments of positive support from the teammates in each group were displayed, students were encouraging one another and accepting the ideas that were flying around. Through the use of communication and being verbal to one another can enrich the student's learning environment.

Challenges of Implementing STEAM Activity

The qualitative analysis of the STEAM activity did bring some challenges that the researcher and teachers have depicted and understanding these challenges is crucial for grasping

the complexities and limitations of employing interdisciplinary approaches in education. The table portrays the themes that were brought forth from the challenging aspect of conducting a STEAM activity.

Theme 1	Time Constraint
Theme 2	Surface Level Integration
Theme 3	Unequal Participation
Theme 4	Artistic Abilities

Table 9: Themes of the Challenges of Implementation

The observation of students during the STEAM activity highlighted challenges in balancing time effectively. The amount of time for the science class was not enough, because the students had a time restraint to finish their green city. Some students rushed to the end of their project when not much time was remaining for the class. Also, when the groups were presenting their green city to the class it was rushed to go through it very quickly because again of the time limitation. The observer also notes how trying to finish up with the STEAM activity can display negative effects on academic performance. Several participants showed concern that the time invested in the art project lessened their focus on the main science or engineering aspects, potentially resulting in lower grades and heightened academic stress. The impact on academic performance raises questions about the viability of effortlessly integrating art with challenging science or engineering topics. The time dedicated to the art component of the STEAM activity seemed very limited, which left some students with a surface-level understanding. The integration of art, while displaying many benefits could also have a disadvantage when it comes to time. The time felt constrained when students were creating their geometric cities and some were not able to color their cities or go into more detail to make their city different and innovative. Therefore, when implementing an art activity in any STEM subject class, teachers need to maintain and balance time when integrating

art into math. Teachers also need to find time for in-depth mathematical study to achieve a comprehensive and meaningful learning experience.

Another challenge displayed through the STEAM activity was discussing surface-level concepts on the importance of green cities. Since the activity was done in the span of one class, basic knowledge was only permitted of the topic. The observer could not delve into deeper understandings and concepts and this approach promotes only surface-level knowledge integration. This limited integration could raise concerns about the effectiveness of using art in a science class in achieving educational goals. From this challenge, teachers should target and focus on strategies to convey deeper and meaningful learning goals to the students if implementing art-based methods in STEM subjects. During the STEAM activity, there was a decrease in some students' focus on some geometry concepts. The integration of art into the math activity might have unintentionally shifted the students' attention away from fundamental mathematical principles. The appeal of being creative and innovative during the activity could have led to a decline in understanding and having accurate shapes of the city. This result emphasizes a potential disadvantage of integrating STEAM activities if not thoroughly aligned with fundamental learning objectives. Some students demonstrated signs of frustration during the STEAM activity, suggesting a potential misalignment with their preferred learning styles. STEAM is under the spectrum of being multidisciplinary, so some students might not be able to relate to this approach, are not used to this approach, or cannot fully resonate with them. Some students prefer learning in the traditional environments so being creative and engaging could lead to discomfort or disconnection to the lesson. Educators need to consider individual learning preferences when designing and implementing STEAM activities guaranteeing that they can accommodate all students. Additionally, observation notes uncovered occasions of unequal participation among students in the group, despite efforts to encourage

collaboration. Some students took on more passive roles during the art project, leading to inequalities and differences in contributing to the collaborative green city activity. The unequal participation not only hampered the overall success of the collaborative effort but also raised questions about the inclusivity and effectiveness of interdisciplinary activities within a varied student population. Another challenge that was presented during the activity was the unequal participation levels of several students. One of the main benefits of using art in a STEM subject is an increase in students' engagement in the lesson, but some students did not fully engage or participate during the activity. This could be credited to students who feel they are not confident in their opinions, may not have any prior knowledge of the subject, maybe they thought it was complicated, or students find the activity boring. This leads to unequal participation in the activity, but that isn't the intention of the STEAM activity.

The last challenge that was presented during the observation process was instances where students expressed frustration with using and implementing different artistic methods or not enough art resources being provided in the class. Some students felt restricted from the materials, deterring their ability to fully realize their creativity within the scientific context. Frustration was raised from this challenge and thus led to the influence of negative emotional tones during specific stages of the STEAM activity. Therefore, this challenge shall be questioned and examined for future reference to be able to adapt and have an accommodating approach when students want to artistically express themselves. The last drawback displayed from the STEAM activity was the terms of assessing and evaluating students. Traditional assessment methods could make it difficult to capture the entirety of student engagement, as the activity ordered a combination of analytical and imaginative skills. Calculating the success of the activity went beyond using and displaying correct geometric shapes; it required pleasure in using artistic styles, expression, creativity, and the

ability to communicate and use mathematical concepts visually. Therefore, the challenge lies in developing proper assessments that deal with the mathematical and art concepts of the activity. This observation portrays how necessary it is to have innovative assessment strategies designed for interdisciplinary projects. Thus, educators need to carefully consider different assessment strategies when conducting STEAM activities.

Conclusion

The results of the qualitative analysis from the observation perspective of the STEAM activity portray positive and a few negative effects of integrating art-based methods into a science and engineering class. These effects encompass challenges in time management, limited integration of scientific concepts, and unequal participation. However, to develop teachers and schools should acknowledge and address these challenges because it is crucial for refining interdisciplinary approaches and ensuring a more equitable and effective educational experience for high school students. In better light, observations and field notes feature the significance of collaboration in the STEAM activity encouraging a holistic and engaging learning environment for the students. The results of the qualitative analysis indicate that integrating art-based methods within a science and engineering class can positively impact students' creative expression, social interaction, and sense of accomplishment. The interdisciplinary approach not only improves their academic experience but enriches their learning environment and promotes lifelong learning. The findings display positive and enthusiastic reactions from high school students. Art’s role as a powerful visual communicator plays a vital part in science simplifying complex scientific concepts, depicting intricate data visually comprehensible, and aiding in the representation of information. Through illustrations, diagrams, and charts, artists help scientists and researchers convey their findings with clarity and precision. Visual representations and data visualizations not only enhance the

accessibility of scientific information but also enable the identification of patterns, trends, and anomalies within datasets. In conclusion, art is an indispensable companion to science enriching it with its capacity to simplify and communicate complex ideas, fostering creativity and innovative thinking, promoting science outreach and public engagement, facilitating interdisciplinary collaboration, and contributing to the cultural significance of scientific endeavors. The integration of art into the realm of science enhances scientific understanding and progress, enriches the human experience, and invites individuals to explore and appreciate the intricate beauty of the natural world and the mysteries that science seeks to unravel. This STEAM activity has exhibited many positive aspects from the students' reactions to engaging in the activity and expressing their learning styles. Students displayed a collaborative manner where they worked in groups and enjoyed working together in the activity. Students were excited and enthusiastic regarding the activity, students displayed their creativity and created unique geometric cities using different colors and shapes. Furthermore, the content analysis revealed the theme of continuous engagement, indicating that students remained fully immersed in the creative process from beginning to end with minimal instances of distraction or even assistance. Overall, this in-depth content analysis offers how STEAM activities can benefit students by promoting collaboration, engagement, creativity, problem-solving, and the cohesiveness of art and mathematics.

5.4 Semi-structured Interviews

The data analysis process involved coding the interview data using MAXQDA, a qualitative data analysis software, to discern patterns, themes, and concepts within participants' responses. Initially, codes were generated based on the research notes taken during interviews, encompassing seven initial codes such as frustration, STEAM integration, district administration, engagement, relevance, partnerships, and challenges. Subsequent rounds of coding revealed additional codes

identified during interviews, necessitating further review and refinement. The researcher meticulously examined and transcribed the interviews and refined the coding structure by incorporating new codes and reviewing existing ones against relevant literature. Using MAXQDA, codes were organized into thematic groups, with quotations attributed to each code subsequently reviewed to establish subcategories. The data was then re-examined to allocate it to appropriate subcategories within respective themes. Quotes associated with each subcategory within a theme underwent thorough scrutiny to ensure alignment with the overarching theme and specific subcategory. This analytical process was applied to both teacher and student interviews, warranting comprehensive exploration and interpretation of the data collected.

5.4.1 Participant Sample

The researcher approached teachers who expressed their interest in participating in the study. These participants were subsequently requested to confirm and fill out the consent form to be involved in the research. The two main criteria encompassed the following two elements:-

1. A high school teacher in the following subjects, math or any science subject.
2. A high school teacher over the age of 25.

Face-to-face interviews were chosen over telephone interviews due to their ability to provide a more naturalistic setting when investigating a social phenomenon, as advocated by Heppner, Kivlighan, & Wampold (1999). These in-person interviews were conducted over one year, spanning from October 2021 to November 2022. Some interviews were recorded audibly and the rest were transcribed. All the interviews occurred in the teacher's classroom or the break room. The principal’s interviews took place in the office of their school. Informed consent for the interview and audio recording were obtained before commencing the interview and initiating the recording

process, as seen in Appendix 2-4. All 23 interviews were voice recorded, and the audio file was erased after transcription. As a result, all interviews for this study were conducted anonymously. Following that, each interview will be recognized by the countries HU- Hungary or PA- Palestine, the interviewee's position- Teacher or Principal; and the interviewee's code number (*e.g.*, HU Teacher 1, HU Principal 1, PA Teacher 1, PA Principal 1,... and so forth). The difficulty in finding and interviewing participants, especially throughout a pandemic and post-pandemic, explains in large part the discrepancy in the number of Hungarian and Palestinian interviewees (teachers and students). The interview durations varied, ranging from 30-40 minutes. The sample of this part of the study comprised 23 high school teachers in Hungary and Palestine regarding their perspective on STEAM education. The teachers were selected through a combination of criteria. The characteristics of the sample are presented in the Table below.

Selection Criteria	**Reason**
Must be teaching at secondary school grade levels	Because there has been less emphasis on teachers' beliefs and practices of encouraging creativity in the secondary school context (Andiliou & Murphy, 2010).
Must be over the age of 25.	Research into the efficacy of teachers indicates that as teachers gain more experience, their effectiveness tends to improve (Kini & Podolsky, 2016). In this part of the research, the objective was to investigate the insights of teachers' perspectives regarding art-based methods in STEM education.
Must be teaching a STEM course, for example, science or math.	During this part of the research, the purpose is to obtain the perspective of a science or math teacher regarding integrating art-based methods in their lessons. They can offer valuable insights into the realities and challenges of incorporating art-based methods, providing a different understanding of their impact on student learning.

Table 10: Teacher Selection Criteria

5.4.2 Teacher Interviews

In this section, the research delves and discovers the themes that emerged from the interview process and the subsequent analysis of the data. The central themes that surfaced after scrutinizing the data from the individual's perspective regarding STEAM education demonstrated a positive learning experience and a few challenges for implementing STEAM into curricula. The research questions were answered throughout the interview process: What are the perspectives of educators and school leaders regarding STEAM education? What are the challenges educators and school leaders face in integrating STEAM education within their educational institutions? How do educators assess the level of significance and long-term viability of STEAM programs within their educational institutions?

Hill et al. (2005) recommend the creation of an interview protocol comprising 10-15 questions, including inquiries, to be completed within a 25- 30 minute time frame. The set of interview questions initially consisted of 10 questions along with several other questions. The researcher wanted to create a strong rapport among the participants therefore, the interviews commenced with simple background questions, per Hill et al.'s (1997) recommendations. These questions sought to make the participant feel at ease, and also in collecting demographic and job title information.

The research questions for the semi-structured interviews' main aim was to gain in-depth insights into the subject matter. These questions are designed to obtain detailed responses from the participants and allow the researcher to explore various factors of the topic. Common themes include understanding participants' experiences, perceptions, and attitudes related to STEAM education. The research questions focus on uncovering rich qualitative data that can inform a deeper understanding of the phenomenon being studied.

RQ1: What are the similarities and differences between teachers' perspectives of students' learning outcomes when integrating STEAM in Palestine and Hungary?

RQ2: How can teachers implement successful STEAM lessons in the classroom?

RQ3: What are the challenges teachers face when attempting to integrate STEAM activities into their lessons?

RQ4: How do students perceive STEAM's benefits and challenges in developing their learning experience?

5.4.3 Results

STEAM education has gained popularity and recognition from educators and researchers regarding its benefits and importance in enhancing a student's learning experience. These are the main themes collected from the teacher's perspectives regarding STEAM education.

Research Question 1: Educators discuss similar values when describing the effectiveness of STEAM education on students' learning outcomes.

The main description and themes that emerged from the teachers' perceptions regarding STEAM education efficiency towards students' learning is that STEAM integration practices support students' learning experiences by focusing on student engagement, shifting the traditional teacher-led model to teacher-facilitated instruction. The table below demonstrates the themes that arose from research question 1.

Thematic Category	STEAM Integration on Students' Learning Outcomes
Theme 1	Creativity
Theme 2	Interdisciplinary Learning
Theme 3	Engagement
Theme 4	Communication Skills
Theme 5	Critical Thinking
Theme 6	Collaboration
Theme 7	Problem-Solving Skills
Theme 8	Hands-on Learning
Theme 9	Long-Term Retention
Theme 10	Growth Mindset
Theme 11	Real-World Applications

Table 11: Themes from RQ 1

Enhanced Creativity

Teachers often find that art-based methods stimulate students' creativity. They encourage students to think outside the box, come up with innovative solutions, and explore the artistic aspects of scientific concepts. This creativity can be a valuable skill in STEM fields. Enhancing creativity in STEM education through art-based methods is a compelling approach, drawing support from various prominent educational theories.

> "Creativity is the livelihood of learning, the very essence that turns mundane information into lifelong knowledge. It's through creativity that we encourage students to question, explore, and discover" (HU Teacher 3).

Similarly a teacher quotes,

> "Creativity is more than just a skill; it encourages students to seek answers, to explore new perspectives, and to make connections that others might overlook. It's the key that leads to a lifetime of learning" (PA Teacher 15).

The first two quotes emphasize the critical role creativity plays in the realm of education. They highlight how creativity transforms the ordinary asset of information into a profound and enduring understanding by encouraging students to question, explore, and discover. Creativity becomes the means of learning which introduces strength and relevance into the educational process. The notion that creativity is not merely a skill, but a method for seeking answers, exploring diverse perspectives, and building connections emphasizes its transformative power in shaping individuals into lifelong learners

Another teacher expressed their perspective by stating that,

> "This world has been increasingly driven by technology, so creativity stands as the last stronghold of human individuality. It allows students to think, feel, and express in ways that technology and other machines cannot. Teachers need to push forth for students to foster being creative" (PA Teacher #18).

Two teachers with similar views about creativity explain that,

> "Creativity can be a versatile tool that should be integrated into every subject. It acts like a bridge between information innovation" (HU Teacher 7).

> "Creativity in the classroom is a necessity because allows the students to be curious and passionate about a subject" (PA Teacher 16).

These perspectives suggest that creativity grants students a unique space for cognitive and emotional expression. They propose that creativity acts as a versatile tool, forming a bridge between the achievement of information and the realm of innovation. Underlining the necessity of creativity in the classroom, another teacher points out its role in fostering curiosity and passion among students. Collectively, these viewpoints connect on the idea that in an era dominated by technology instilling creativity becomes a pedagogical imperative.

The Principal of the Palestinian school stated,

> "Creativity is not only about painting pictures or doing arts and crafts; it's about creating new ideas and painting solutions. It's a universal language that every student should learn to speak."

Another teacher expressed their opinion about creativity,

> "We should nurture creativity to students and empower them to become critical thinkers, compassionate individuals, and imaginative problem-solvers" (HU Teacher 6)

Likewise, PA Teacher 19 voiced how,

> "Creativity is the spark that changes passive learners into active participants. Students can begin to embrace every challenge as an opportunity to create, explore, and grow."

The principal and the teachers collectively advocate for a universal understanding of creativity in education. They delve into creativity that goes beyond traditional artistic expressions portraying how it equips students to formulate new ideas and solutions and the importance of fostering creativity to promote critical thinkers, compassionate individuals, and imaginative problem-solvers. Furthermore, they also suggested how creativity transforms passive learners into dynamic contributors. The overarching message that emerges from these educators is that creativity is a complex tool, not only enabling students to engage in artistic endeavors, but training them with the skills to navigate challenges, grow, and actively contribute to their learning journey.

> "Creativity isn't just for students who are already artistically gifted, but for everyone. It has the ability to adapt, rethink, and reimagine how students perceive certain issues that are constantly evolving" (PA Teacher 21).

HU Teacher 12 conveyed,

> "When implementing creativity in the classroom, it could empower students to question real-life scenarios. Can help them find their voice and encourage them to make a difference."

Creativity in the classroom can be very vital as portrayed from these teachers' perspectives. It catalyzes engagement and effective, and holistic education. It empowers both students and educators to exceed the boundaries of traditional teaching and learning methods. By promoting creativity in the classroom, educators can create an environment that nurtures curiosity, exploration, and critical thinking. Creative classrooms can celebrate diversity of thought and expression, and inclusivity by recognizing and valuing students' perspectives. Essentially, creativity in the classroom is not just about producing art; it's about nurturing experienced and innovative thinkers who are equipped to face the challenges of the future. Therefore, teachers should embrace creativity as a positive educational tool, where it allows students to become active and independent learners.

These quotes and opinions underscore the immense significance of creativity in education, emphasizing how it nurtures interest, resilience, innovation, and critical thinking, and equips students with new skills to use in their future.

Interdisciplinary Learning

Art-based methods promote interdisciplinary learning by combining the analytical thinking of STEM with the creative thinking of the arts. Teachers appreciate that this approach helps students make connections between seemingly unrelated subjects. Interdisciplinary learning, which integrates multiple academic disciplines into a unified educational approach, is strongly grounded in various educational theories that emphasize the importance of holistic and interconnected knowledge acquisition.

Starting with some teachers (HU Teachers 7, 13, PA Teachers 14, 15) emphasized how students can develop their learning experience when weaving art into traditional subjects, as illustrated by these words:

> "Interdisciplinary learning through art is a journey that exceeds the boundaries of traditional subjects. It encourages students to explore the connections between math, science, or history, and the arts can adopt a more comprehensive understanding of the world" (HU Teacher 13).

Other teachers highlighted that interdisciplinary learning with art can encourage students to think, explore, and innovate across various fields (HU Teachers 2, 11, PA Teachers 15, 21). These teachers emphasized the role of art in the classroom where it,

> "It cultivates well-rounded individuals; students have different abilities and interests, and when a student is creative in a certain area, we [teachers] should try to identify and support them" (PA Teacher 21).

Similarly, a HU Teacher 11 stated,

> "Using different art-based methods in interdisciplinary learning is not just about producing beautiful pieces; it's about creating accomplished students who can steer the difficulties of the modern world by drawing on a wide range of knowledge and skills."

A few teachers have supported the thought that interdisciplinary learning can instill lifelong learning in students (HU Teachers 11, 12, PA Teachers 13, 23).

> "When trying to teach interdisciplinary learning through art, it isn't only about instructing knowledge; it's about teaching a lifelong love for learning. It should nurture students' ability to think critically and make connections" (PA Teacher 23).

> "Art can be an integral part of interdisciplinary learning and can spark creativity, curiosity, and critical thinking allowing students to explore the intersections of knowledge and wanting to continue to learn" (HU Teacher 12).

Additionally, some teachers have expressed that interdisciplinary learning is a balance of using multiple intelligences (HU Teacher 5, 10, PA Teacher 16, 22).

> "Interdisciplinary learning should develop a balance between left-brain analytical thinking and right-brain creative thinking, making students more multitalented and adaptable" (HU Teacher 5).

> "Art adds color to interdisciplinary learning, making it a deepening and multidimensional experience. It uses the multiple intelligences creating a sense of balance" (PA Teacher 22).

The journey towards embracing interdisciplinary learning comes with its challenges. One significant challenge lies in the potential development of uncoordinated curricula. Integrating multiple subjects seamlessly requires a careful balancing act to ensure that the interdisciplinary approach enhances the depth of knowledge in each subject area. Achieving this demands accurate and thorough planning and collaboration among educators to design curricula that are both comprehensive and well-integrated. Additionally, another challenge is having effective collaboration among teachers from diverse disciplines; breaking down traditional subject-specific teaching may cause difficulties in supporting teaching methodologies and assessment strategies. To overcome these obstacles, schools require a change where that highlights the importance of collaboration and shared goals for both educators and administrators. Teacher competencies become a crucial factor in the success of interdisciplinary learning. Educators must not only be experienced in their respective subjects but also have the skills to connect and integrate diverse fields of knowledge. Professional development opportunities that focus on interdisciplinary teaching strategies and methodologies are necessary to train teachers with the necessary competencies for successful implementation.

Thus, art plays a pivotal role in interdisciplinary learning by adopting creativity, critical thinking, and a universal understanding of various subjects. Its significance provides a unique perspective on complex topics. This approach encourages students to think outside the box, promoting problem-solving skills and a deeper comprehension of the interconnectedness of knowledge. In essence, art enriches interdisciplinary learning by broadening students' horizons, encouraging innovation, and cultivating a wide education.

Engagement

Art-based methods like drawing, painting, or creating music can engage students in ways that traditional lectures and textbooks may not. Teachers notice that students become more enthusiastic about STEM topics when they are presented in a visually appealing manner. Engagement in education is a vibrant concept that transcends both old and new educational theories while being continuously informed by cutting-edge research. Many teachers have conveyed that when using art-based methods it promotes engagement from students in their classroom.

PA Teacher 14 stated,

> "Engagement is the heartbeat of learning, with art-based methods it can allow students to want to be involved in the classroom more."

Likewise,

> "When we, teachers, integrate art into education, we can try to transform the passive students to more active. Active participation can be created in the classroom" (HU Teacher 9).
>
> "It's about turning observers into performers and explorers" (PA Teacher 16).

This quote is similar to Augusto Boal, a prominent Brazilian theater practitioner and disciple of Paulo Freire who transformed the theatrical landscape with his powerful concept that *"spectators turn into actors".* This transformative idea lies at the core of Boal's renowned method in the Theater of the Oppressed where he envisioned theater as a powerful tool for social change demonstrating how the traditional boundary between performer and audience dissolves. In this concept, spectators aren't passive observers, but they become active participants in the unfolding drama. Boal's approach encourages individuals to engage with societal issues promoting empowerment and action. Through techniques such as Forum Theatre, Boal invites participants to step into the shoes of the oppressed to explore alternative solutions and challenge oppressive structures.

Most of the teachers have shared related perspectives when implementing art-based methods it can enhance the student's learning when they start engaging in the classroom (HU Teachers 3,5,6,7,8, PA Teachers 13,14,15,17,18,19).

> "Art-based methods are the scope of engagement in education. It empowers students to immerse themselves in the learning process" (HU Teacher 5).
>
> "Art-based methods add a layer of excitement and discovery that makes education an adventure rather than an obligation" (HU Teacher 7).
>
> "When students engage in the classroom it allows students to wonder, explore, and feel interest in the subject" (PA Teacher 18)

From these teacher's perspectives using art-based methods in education extends the scope of engagement by providing students with a dynamic platform to immerse themselves in the learning process. Teachers can transform the classroom into a space where students not only fulfill academic obligations but have a sense of discovery which fosters a genuine interest in the subject matter that creates a rich and fulfilling educational experience.

Palestinian teachers also shared similar views to Hungarian teachers, for instance,

> "Art-based methods can draw students into the learning process, making it personal and memorable, it can also transform their learning experience" (PA Teacher 14).
>
> "When trying to use art-based methods in the classroom, it can become an invitation to students to contribute more, and to perhaps have a deeper understanding of world applications" (HU Teacher 5).
>
> "Engagement through art-based methods allows students to the different wonders of education, and transforming their imagination and discovery and begin to learn in multiple ways" (PA Teacher 18).
>
> "When students begin to use art in the classroom, I feel students will want to engage because maybe that will empower them to want to ask questions or discover new learning possibilities" (HU Teacher 19).

Engagement through art-based methods in the classroom is quite significant as it not only enhances the learning experience but also encourages a more profound understanding of the subject matter. Art has the unique ability to captivate students' attention, making lessons more enjoyable and memorable. When students are actively involved in creating art, whether through drawing, painting, drama, or other creative mediums, they are more likely to engage. Therefore, when

integrating art into the classroom not only increases student engagement but also contributes to a more comprehensive and enriching educational experience.

Improved Communication Skills

Art-based methods can improve students' communication skills. Teachers find that this enhances students' ability to explain their ideas effectively. Enhanced communication skills are increasingly recognized as a critical competency in the modern world, extending far beyond the confines of traditional educational theories. Effective communication is an important asset for success in almost every aspect of life, from personal relationships to professional endeavors. Consequently, the Hungarian and Palestinian teachers have indicated that improved communication skills can be enhanced when integrating art-based methods into the classroom.

> "Art-based methods provide a unique platform for students to improve their communication skills. It's not just about creating art; it's about expressing their thoughts and ideas and conveying their opinions effectively" (HU Teacher 5).

Comparably, two PA Teachers stated,

> "Art-based methods are a medium for self-expression and communication. It can empower the students to articulate their thoughts" (PA Teacher 16).

> "Art is not just about creating or an extra-curricular activity, it allows students to be able to express themselves through different methods like through drawing pictures, or telling stories. It allows students to be unique" (PA Teacher 23).

All the teachers feature the significance of art-based methods as a unique platform for enhancing students' communication skills. They emphasize the importance of expressing thoughts and opinions effectively. HU Teacher 12 expressed that,

> "Using art in the classroom enables students to communicate through their emotions and ideas without their words through diverse art-based methods. Through art, students can receive and offer a fresh and creative when connecting with their classmates."

Few Hungarian and Palestinian teachers have articulated that students can benefit from using art-based methods in the classroom, for instance,

> "Art-based activities, such as visual arts, drama, or creative writing, encourage students to think critically about how to communicate their concepts visually or through performance. This challenges them to make deliberate choices about certain colors, symbols, and expressions" (HU Teacher 8).

> "Art also offers a safe and non-judgmental space for students to express their feelings and ideas" (PA Teacher 15).

Furthermore, teachers professed that when students are doing art projects can promote better communication skills, for instance,

> "When students work together on projects, they are discussing with each other and this leads to sharing their ideas. This teaches students how to listen, compromise, and give constructive feedback to their group mates and this is an effective tool to improve communication skills" (PA Teacher 21).

In conclusion, implementing art-based methods develops students' communication skills by encouraging creativity, collaboration, and self-expression. Teachers are the first to witness the positive impact these methods have on their student's ability to communicate effectively in various contexts.

Critical Thinking and Problem Solving

Art-based methods often involve problem-solving, critical analysis, and attention to detail which are essential in STEM fields. Teachers observe that students develop these skills when using art in a science or math class. Integrating art-based methods into education has proven to be a powerful method for cultivating critical thinking and problem-solving skills. When asking the science teachers about implementing art-based methods and their usefulness they stated (HU Teachers 1, 6,10, PA Teachers 12, 20, 23),

> "Art-based methods can promote critical thinking and problem-solving. It can offer the students the tools to analyze, question, and create solutions" (HU Teacher 1).

> "Incorporating art into education is like planting the seeds of critical thinking and problem-solving. It nurtures young minds to analyze, innovate, and adapt to the changing of knowledge" (HU Teacher 12).

> "When administering different art-based methods to students it can teach them to view the world through a critical lens, to interpret, and to create innovative solutions, which is a powerful approach" (PA Teacher 20).

Another angle a few teachers have concluded about critical thinking skills when using art-based methods is the idea of independence.

> "Different types of art can create meaningful connections, and interpretations, and develop their ability to find solutions on their own" (HU Teacher 9).
>
> "Students can try to solve problems independently in a critical thinking manner. They become encouraged to try to analyze and question different and new concepts from their lessons" (PA Teacher 18).

Another idea was passed around about how the students can become deep thinkers when using critical thinking skills. As quoted from HU Teacher 11,

> "Incorporating art into education isn't only meant to ensure creativity, but also for critical thinking and problem-solving skills and allowing the students to become deep thinkers who can assess and address real-world issues."
>
> "Using art in the classroom can begin the process that empowers students to think deeply by asking questions and by exploring new concepts and ideas" (PA Teacher 13).

Lastly, teachers found students being challenged when using new methods in the classroom which stems from critical thinking,

> "Students can begin to start challenging different ideas and science concepts when using different tools and methods, like art" (PA Teacher 15).
>
> "Art education can encourage students to approach challenges with an open mind, and have an inventive mindset" (HU Teacher 7).

Concluding this theme, art often involves problem-solving, as students face challenges in their learning and must find innovative solutions. This process of experimentation and adaptation enhances their ability to analyze and assess. Art-based methods also promote open-ended questioning and discussion which aid students to explore different perspectives and interpretations. When discussing their work with others, they commence to develop their capacity to think critically about the meaning and context.

Collaboration

Collaboration is a pedagogical approach that is gaining recognition and prominence in modern research. In STEM, where technical knowledge often dominates, collaboration with art can help break down these traditional methods by promoting creativity and innovative thinking. Many of the teachers suggested how collaboration is an important tool for using art-based methods in lessons (HU Teachers 2,4,7, PA Teachers 13,16,17).

> "Collaboration is one main factor that can come from using art-based methods in a subject or during the lesson. It can allow students to work together, maybe share their ideas together" (HU Teacher 4).
>
> "Teaching the students with some sort of art method can teach them the value of teamwork" (PA Teacher 16).

Hungarian teacher 7 also added that when,

> "Using art in the classroom can promote a collaborative journey with the students, and it can equip the students with the skills to create and come together and communicate freely among each other."

Another idea that came from the theme of collaboration was the idea of shared learning. A few teachers have mentioned this thought, firstly,

> "I mean from the obvious point of view when using art it shows individual creativity, but it can also show a shared learning experience among the students" (HU Teacher 8).
>
> Similarly, "In the world of art, collaboration is essential. Students learn together and can share a similar learning experience in the classroom" (PA Teacher 15).
>
> "Collaboration can inspire students to want to work together, to want to have a similar learning experience, and problem solve together in their group" (HU Teacher 10).
>
> Additionally, "When students start collaborating with one another, I feel they get excited to learn and want to be part of the learning experience. Students might feel they have a chance to express themselves among each other and feel like they create something powerful when working in a group. They are collecting ideas together and creating something unique among each other in their group" (PA Teacher 21).

Some teachers expressed how collaboration is linked to diverse perspectives and opinions regarding a certain topic in the classroom (HU Teachers 10,11, PA Teachers 14,15).

> "During an art activity, it can be collaborative experience because when students begin engaging with one another they start sharing their perspectives and ideas. It shows how each student's ideas are different and they can relate it to each other" (HU Teacher 10).

> "Students begin to express themselves to their teammates, and begin to take on different ideas from each other" (PA Teacher 14).

Comparably,

> "Students begin to appreciate their teammate's opinion regarding the topic, diverse ideas begin floating around in their groups and listening to each other is a vital aspect during the collaboration process" (HU Teacher 11).

Lastly,

> "Collaboration is a celebration of diverse perspectives from the students. Students will have the urgency to want to share their opinion and listen to their classmates" (PA Teacher 15).

Therefore, collaboration is an essential component of the effectiveness of art-based methods in STEM education. It promotes creativity, improves communication skills, and raises diversity in students' opinions regarding a certain concept.

Hands-on Learning

Many art-based methods involve hands-on, experiential learning. Teachers appreciate that this type of learning can make their students attain certain concepts in a more accessible and memorable way. Hands-on learning when integrated with art-based methods has gained an effective tool when trying to engage students in the lesson. Throughout the interviews, many teachers have shown interest in this concept and how it goes hand in hand with art-based methods.

> "Hands-on learning through art-based methods is a way for students to feel or touch or experience knowledge in a more impactful way" (HU Teacher 2).

Likewise, Palestinian teacher 19 stated,

> "Learning through the arts can enable students to dive into the creative process, experiment, and discover the benefit of learning through a more hands-on approach"

> "Through art-based methods, students can start maybe to feel curious and could start questioning things and this would make them want to have more of a want to learn and perhaps experience new things. This can transform their way of learning when it becomes active and they have a direct link to learning" (HU Principal 1).

One common theme that teachers discussed about hands-on learning was that it allows students to have a personal connection to knowledge and learning.

> "I believe it's about forming a personal connection to their learning experience where students are actively involved in the classroom" (PA Teacher 18).

The idea expressed by PA Teacher 18 about hands-on learning encouraging a personal connection to knowledge supports the principles of constructivist learning theory. Constructivism emphasizes that learners actively build their understanding of the world through personal experiences, interactions, and reflections. Therefore during hands-on learning experience, students engage directly with materials and activities by creating a bridge between theoretical concepts and tangible experiences. This further connects with the constructivist notion that knowledge is not passive, or active because individuals will interact with their environment. Both hands-on learning and the constructivism learning theory highlight the importance of active engagement and personal involvement in the learning process.

> "When students are having a hands-on learning experience, it allows them to have a deeper and richer understanding because it becomes personal to them and more meaningful" (HU Teacher 11).

> "I think students can begin to explore new concepts when using art, so when they start exploring and becoming active in a project or the lesson, they begin to have a more in-depth or like a hands-on experience where they are challenged by the topic and can interact with different concept of the lesson" (PA Teacher 17).

Furthermore, exposure to STEAM familiarizes students by cultivating their interest and aspiration toward STEAM fields.

> "I think students can sometimes feel overwhelmed when a lot of information is being pushed in them, so by giving them an activity maybe dealing a little bit with art can help them feel a more closer connection to the material, they can slowly ease into the subject and maybe begin to feel creative and want to experiment with new ideas. This approach is yes- a more hands-on approach, that I have come to see can work on students, especially in a science lab class" (HU Teacher 3).

In summary, hands-on learning can enhance a student's engagement, deepen understanding, and promote critical thinking. Active learning has become a popular learning method because it can equip students with new skills, a meaningful learning experience, and a personal connection to

the material. In conclusion, a hands-on learning experience provides opportunities for perceptible exploration and many possibilities within STEAM fields.

Long-term Retention

Teachers find that students are more likely to remember certain concepts when integrating art in the classroom. This could aid with long-term retention and understanding of complex subjects. Long-term retention is a crucial aspect of effective education because the role of art-based methods enhances this dimension of learning for the students. Many teachers have expressed how long-term retention comes from using art-based methods in the lesson. For instance,

> "Having art-based methods in a lesson can improve students' long-term retention of the topic. Students can have a deeper understanding to the subject that will last for a long time" (HU Teacher 11).

Art-based learning engages numerous cognitive competencies, including memory and attention, contributing to a more universal understanding of complex subjects. In terms of memory development, when creating art it involves both the encoding and retrieval of information. When students visually represent concepts through art they are actively encoding the information in many ways, which can enhance memory merging. The hands-on nature of art creation also involves kinesthetic learning, reinforcing memory through physical engagement. Additionally, attention is crucial in the artistic process because when students use art they can focus on details, techniques, and the overall composition. Then they can transfer to other learning tasks that can improve concentration and cognitive focus. Ultimately, art-based learning is multi-sensory and experimental which encourages critical thinking, problem-solving, and the exploration of alternative perspectives.

Likewise,

> "Art is a powerful tool to use in the classroom, because students will engage more and can remember the information learned in the classroom for a longer period of time" (PA Teacher 22).

Another teacher expressed that,

> "Art-based methods can sustain long-term retention by engaging students' multiple senses, so in a way, it is not just about learning; it is about them experiencing something new and become creative" (HU Teacher 6).
>
> "From long-term retention of knowledge students are able to touch, see, and feel regarding certain topics in the science class and this lasts long in their memory for many years" (PA Teacher 18).

A few teachers have also voiced that using arts in the classroom can lead to long-term retention which leads to students having a personal experience in the learning process (HU Teachers 4,5, PA Teachers 16,20).

> "By engaging students in their learning process, it allows them to use this knowledge and mixed it into their personal experiences which allows students to remember things better for future references" (HU Teacher 4).
>
> "It allows students to create memorable learning experiences when using art, which makes it more personal because they are adding their own touch to their learning experience" (PA Teacher 16).
>
> "I mean in my opinion when I incorporate some sort of art method in my class, I feel students have a memorable experience and will remember the information they learned better, which leads them to have a personal experience in the class, which again will be with them for a long time" (PA Teacher 20).

The last sub-theme teachers stated from attaining long-term retention using arts was the life-long learning process (HU Teachers 7,9, PA Teachers 22, 23).

> "Art-based methods empower students to not just learn, but to experience and create, making knowledge a valued and special part of their lifelong learning journey" (HU Teacher 7).
>
> "When I did a science experiment that implemented a some sort of art I felt students engaged more and were more creative, the information didn't just enter one ear and leave, I felt it imprinted in their memory and I think if using more art in their learning it can become a life long process for them to keep learning" (PA Teacher 22).
>
> "Students will begin to have a noteworthy learning experiences when students begin utilizing visualizations and this creates a lifelong lesson to remembrance" (HU Teacher 9).

In conclusion, long-term retention could come from using art-based methods in the classroom. The teachers have suggested that using different forms of art allows creativity, remembrance of specific information, a personal connection to their learning experience, and life-long learning.

Fostering a Growth Mindset

Teachers seemed to appreciate when adding arts into their lesson how it fosters a growth mindset which encourages their students to embrace challenges and view mistakes as opportunities for learning. Therefore, the integration of art-based methods in education can effectively nurture and grow a student's mindset. Many teachers during the interviews have presented the theme of fostering a student's growth mindset (HU Teachers 2,4,7, PA Teachers 18,19,21).

> "I fully believe that the arts can nurture and grow a student's mindset. It empowers the students to embrace challenges and their failures, and this can lead to their potential for growth" (HU Teacher 7).
>
> "When teachers try to incorporate art into education it can teach students that their effort and practice in the classroom can lead to their improvement, which yes leads to development in their mindset" (HU Teacher 2).

Similarly, PA Teachers 18 and 19 stated,

> "Art goes beyond just students' creativity; it improves and grows the students' mindset. Students can learn that their skills can progress to something better, but better yet challenge them to expand their learning abilities."
>
> "Art instills students to believe that they can develop and put more effort into their learning experience. It can develop their talents."

Furthermore, HU Teacher 4 suggested that

> "Art is proof to the power of a growth mindset. Again, as I mentioned art encourages students to see challenges as opportunities so they can learn and approach different concepts in determination."

Lastly,

> "Art leads the students to improvement and seeing the challenges as a way to learn from, even if they make a mistake, they are able to find ways to learn from and this leads to continuous growth" (PA Teacher 21).

To sum up, when implementing art-based methods in the classroom students can develop and grow their mindset from learning through different methods. It allows students to feel challenged in the classroom and leads them to improvement in their learning experiences.

Real-world Applications

Integrating art into education can help students see the real-world applications of their learning. Teachers can use art to demonstrate how it is used in fields like architecture, design, or medical imaging. The incorporation of art-based methods in education holds substantial importance, particularly in the context of real-world applications. Many teachers have demonstrated through the interviews when using art in the class it can relate to their real-life experiences (HU Principal and Teacher 1,8, PA Principal and Teacher 12,15.

> "Students begin to see the practical relevance of what they're learning in the classroom from using art, making their education more meaningful" (HU Principal 1).
>
> "When you begin incorporating real-world applications into art-based methods it opens a whole new set of skills that deal with practical and every scenarios allowing their learning experience to be purposeful" (PA Principal 12).
>
> "When you use art in the classroom students will apply their creativity and problem-solving skills to something more tangible and relevant" (HU Teacher 8).

Similarly,

> "When it comes to real-life instances students will rely on it more than just textbooks because students can start using what they learned in an actual setting in their daily life" (PA Teacher 15).

STEAM educators emphasize the significance of real-world connections in facilitating student engagement with instruction. Two more participants stressed the importance of STEAM integration in forming tangible links to real-world situations.

> "Real-world applications in art-based methods stir students' curiosity. It does provide a bridge between theory and practice where students can apply their creative abilities to solving actual and real-life problems, making their learning authentic" (HU Teacher 9).
>
> "When applying real-life instances in students' learning, it can prepare them for the different challenges that they can face and it can equip them with the proper tools for their future endeavours" (PA Teacher 20).

In summary, teachers view STEAM education as a valuable way to make subjects more engaging, accessible, authentic, and relevant. When teachers insert instruction within realistic settings STEAM helps students develop a wide range of skills, from creativity, communication,

collaboration, critical thinking, and problem-solving, growing their mindset, and applying real-life occurrences which ultimately prepares them for success in STEM fields and beyond.

Research Question 2: Initial integration of STEAM activities in education.

Each participant recounted their personal insight into how STEAM can be initially integrated into education. This refers to the constructivist learning theory (Vygotsky, 1978), on how individuals construct knowledge based on their experiences. The findings demonstrate the teacher's insights on how STEAM can be integrated into education. The table shows a summary of the recurring themes mentioned by the teachers.

Theme 1	Guest Artist/Art Teacher Lectures
Theme 2	Art-Filled Science Labs
Theme 3	Artistic Data Visualization
Theme 4	Science Fairs/Exhibitions
Theme 5	Group/Project-Based Learning

Table 12: Themes from RQ2

Guest Artist Workshops

Commencing with the first theme, teachers were inquired about how to implement STEAM integration, by highlighting the implementation of guest artist workshops. These workshops are an innovative approach that has gained recognition for its potential to enrich the learners' learning experience. During the interviews, teachers discussed this form of approach on how it promotes creativity, collaboration, and a deeper understanding of STEM concepts to students. Guest artist workshops involve inviting professional artists to collaborate with students by artistically providing fresh perspectives and expertise. Many teachers have insisted on this approach because they feel they do not have the proper knowledge or information regarding art (TH#2,9,10, TP#14,17,21).

> "I am no expert when it comes to art, so I guess I would say bringing in an artist or art teacher to give a workshop or as a guest lecture. They probably have more experience and methods to use art

> in a classroom, so I would say this can bring students to enjoy their learning and feel creative" (HU Teacher 2).
>
> "I mean as a Math teacher, I don't think I ever used art so I will definitely not know how to use it, so like bringing an art teacher or a guest that knows how to use art in Math, I think would be useful because students can actually learn something from a professional in way I can't. I also think it would promote their engagement in the classroom and start being creative and innovative" (PA Teacher 17).

Similarly,

> "I am a math teacher, so sometimes it is hard to come up with ways to use art and math together, but maybe inviting a fellow art teacher or guest can try to bridge the gap between these two subjects, they may have more experience and knows different techniques to implement in the classroom. They can share with the students real life issues and allow them to connect with their inner artistry and try to incorporate it in the math class" (PA Teacher 14).
>
> "I would say inviting someone to the classroom who has a wider range of knowledge to show how art can be used in the classroom, they can offer the students a chance to learn through art that I may not be able to" (HU Teacher 9).
>
> "If a guest artist came it could give the students the opportunity to gain knowledge and information from them on how to use art and how it can benefit their learning experience" (HU Teacher 10).

Lastly, PA Teacher 21 also expressed a similar perception of a guest artist or art teacher,

> "I may have some ideas you know you can find online on how to use art, but maybe once in a while to invite someone who studied the subject can have a greater impact on the students and can teach them to connect art in their lesson, start feeling creative, and maybe inspire students to think differently."

Guest artist lectures can play a crucial role in enhancing STEM subjects by offering unique perspectives and insights that complement the traditional academic curriculum. These lectures can provide students with the opportunity to bridge the gap between science, technology, engineering, and mathematics with the arts and humanities. Guest artists bring their creative and innovative thinking into the STEM classroom which can inspire students to think outside the box or problem-solve creatively. Additionally, allowing these guest artists or art teachers can create for them exposure and encourage diversity in STEM by showcasing successful professionals from diverse backgrounds, promotes inclusivity. To sum up, guest artist lectures can enrich the learning experience, promote creativity, and develop a deeper understanding of STEM subjects.

Art-filled Science Labs

Art-filled science labs in STEM education offer a dynamic and innovative approach that is influential in enriching the learning experience for students. These labs create a creative environment that surpasses the traditional ideas of science and art. Integrating art into the scientific setting encourages students to approach problems with a fresh perspective, explore their imagination, and find solutions to scientific challenges. A few science teachers expressed their interest in an art-filled science lab (HU Teachers 5,8, PA Teachers 15,22),

> "Art-filled science labs are like having a breath of fresh air for science education. I can see that it allows students to feel inspired creatively and have different perspectives presented to them" (HU Teacher 5).
>
> "It can allow students to use their artistic talents to visualize and understand scientific experiences, turning these abstract ideas into memorable experiences" (PA Teacher 15).
>
> "I think students begin to apply their creative skills into learning different science ideologies so that it becomes practical for them and for excited to learn about the subject" (HU Teacher 8).
>
> "Using art in a science lab can really bring out the students' inspiration to learn and be creative. It can be informative, yet enjoyable for them" (PA Teacher 22).

Moreover, art-filled science labs can make the learning process more engaging and enjoyable. The use of color, design, and visual elements a the lab setting can attract students' attention and enhance their interest in the lesson. This can be especially beneficial for students who view science daunting or boring, but when art is incorporated it can bring them excitement and fun to their educational journey. In a STEAM-oriented setting, the emphasis on gaining experiential knowledge and fostering creativity through play finds a parallel in the educational benefits derived from drama. Both approaches recognize that hands-on and immersive experiences contribute drastically to the learning process. In drama, students actively engage with scenarios and role-playing raising a deeper understanding of complex subjects. Correspondingly, in art-filled science labs, incorporating color, design, and visual elements not only captures students' attention but can change the learning environment into an engaging space where experimentation becomes a form

of creative expression. The convergence of these principles underlines the combination between STEAM education and drama.

> "Not all students are interested in science and some may find it boring, but when you add something fun to it like art, the students can become more interested in the subject and actually enjoy the lesson and begin to engage in the material" (PA Teacher 23).

> "Science is already a visual subject, so when actually integrating art into students can learn better, especially in a lab students prefer to learn through doing things than just listening. I see students become more engaged in the lesson when they see something visually that can aid in their understanding of the topic" (HU Teacher 3).

In conclusion, art-filled science labs enhance creativity, engagement, and interest preparing students for challenges and opportunities. These teacher opinions emphasize the profound importance of having art-filled science labs because as mentioned it can empower students to combine their artistic skills with scientific exploration to gain a deeper understanding and appreciation for learning.

Artistic Data Visualization

Artistic data visualization can connect science and art enhancing the learning process in several key ways. Firstly, it tackles complex scientific data to become more accessible and engaging for the students. These types of data visualization can include colorful charts, infographics, PowerPoints, or posters. Most of the science teachers during the interviews have portrayed how they often try to incorporate artistic data visualization in their classrooms.

> "When we want to do a science project, students have the chance to create a poster or PowerPoint to present their topic, this can promote creativity and allow them to feel more engaged in the lesson" (HU Teacher 3).

> "I usually like to do some science project or experiment where students need to create something artsy, I find that students can express themselves more, feel creative, and use different tools to make their project visually better" (PA Teacher 22).

> "I like when students kind of have the freedom to create what they want when it comes to a science project, they can create a poster or an infographic that show their creativity and imagination. Students will spend yes a bit more time on it, but I think it engages them in the topic more" (HU Teacher 11).

Furthermore, artistic data visualization encourages critical thinking, presenting information effectively, and communication skills. For example, scientists who can present their research in a visually appealing and relatable manner are more likely to inspire and connect with people.

> "When students finish their projects, usually a presentation follows, so this helps with their public speaking and are able to explain their thoughts in an effective way" (HU Teacher 5).
>
> "With student projects, lots of student of course get as creative as they can be, but then when they present their project this can develop their speaking and communication skills in front of the class. They also learn how to present to their peers which can benefit them for their future" (PA Teacher 14).

In conclusion, artistic data visualization is a valuable component of STEM education and these quotes and opinions from the teachers emphasize the importance of implementing such art-based methods in education. As mentioned, it empowers students to convert data into visually appealing representations, delving into a deeper understanding of complex information, promoting creativity, public speaking and communicating skills, and how to present material effectively.

Science Fair/Exhibitions

Science fairs hold surprising significance for art education by encouraging creativity and interdisciplinary thinking. Students participating in science fairs often need to create visually appealing and informative displays to effectively communicate their scientific experiments and findings. Most of the science teachers have provided the importance of having a science fair where art is implemented (HU Teachers 3,6,8, PA Teachers 13,18,23). Starting with HU Teacher 3 which implies how science fairs can benefit the students and the usage of art,

> "Science fairs can connect science and art because students begin to construct their poster about a science topic through an artistic approach to compel people to approach them."
>
> "We have done science fairs in the school and I think it helped the students to be creative and let out their inner artistry. Students feel more motivated and engaged to learn the topic when they know they need to present or if there is a reward for having the best project in the science fair, so yes I would say art is very much involved in these science fairs" (PA Teacher 13).

As mentioned before, students begin to develop their communication and presentation skills when they are presenting their projects.

> "Students will build their presentation skills and be able to communicate to people when they are discussing their project to people" (HU Teacher 6).

Similarly,

> "I can see shy students coming out of their shell in science fairs because they feel motivated to present what they worked hard on, especially if there is a reward involved {laughs}" (PA Teacher 18).

> "Science fairs are when students can go all out with their artistic abilities, the more visually appealing it looks like the better their project becomes, we love seeing color, different visuals, and creativity in these fairs" (HU Teacher 8).

Lastly, PA Teacher 23, also conveyed how science fairs depict students' creativity,

> "Science fairs are a great way for students to be creative and delve into the art realm, the bigger and bolder the better their projects will be. I try to tell them to make it as visually artistic and neat as they can because that is how they attract people to listen to their project and make them interested."

Overall, science fairs play a vital role in art education by promoting creativity and developing presentation and communication skills. They create an environment where art becomes a powerful tool for scientific communication and exploration. Therefore, these are a few quotes and opinions from teachers emphasizing the significance of implementing art in science fairs. Students become motivated to create innovative projects and ideas promoting a fun and informative learning experience.

Group/Project-Based Learning

Educators perceive STEAM integration as incorporating project-based learning. Group projects offer numerous benefits for students, such as promoting collaboration and teamwork where students work together on projects that involve artistic elements, students learn to connect their strengths with their classmates and then can share their ideas, and communicate effectively. Five participants articulated how STEAM integration involves opportunities for project-based learning.

> "When students begin to work in a project together it allows them to learn how to work with one another and share their ideas with one another" (HU Teacher 2).
>
> "Students will learn the impact teamwork has which can help them in their future education and careers" (PA Teacher 18).

Similarly, these three teachers mentioned the impact of teamwork,

> "I believe the power of teamwork because it is very beneficial to learn how to work with other people and be a team player, it will aid them in their future and most importantly in their career" (HU Teacher #5)
>
> "Each students has their strengths and weaknesses so by have group projects they are able to put their strength of they know to help their teammates and also to learn from them" (PA Teacher 17).
>
> Likewise, "Students who know things more than the other can teach them that specific thing and vice versa" (HU Teacher 11).

Some teachers and principals have mentioned when doing group projects students with artistic talents can help their classmates which promotes creativity and innovation.

> "Students with certain artistic capabilities can help other students who might not have much interest or know how to use art in a certain project. This can show how each student is different and try to be creative" (HU Teacher 10).
>
> "After seeing some group projects from different grades, you cannot deny the importance of teamwork presented, but also using different art methods into their project to make it appealing to their classmates and how unique and different their project is compared to other teams" (HU Principal 1).
>
> "I can highly vouch for group projects because it is a great way to involve students in the learning process, allows them to learn the idea of working and coming together, and lastly allows creativity to flow among each other. Students can express themselves through art and use it in their project" (PA Principal 13).

Two teachers have expressed that projects can aid students in learning how to work together and can benefit them in their future careers.

> "Weak students work with the strong students and vice versa promotes collaboration and learning among each other, which is very beneficial for the students especially in a project-based learning activity" (HU Teacher 9).
>
> "They can be more confident in the future, they practice their speaking skills in the future. It promotes students to present in front of the class even if they are shy. It will help them a lot and the best part of projects is that each student gets to be creative and they merge their ideas together" (PA Teacher 22).

Some teachers think that PBL is an innovative teaching method that needs to be implemented in classrooms, especially in today's generation. HU Teacher 4 explains,

> "PBL is an innovative and new form of teaching. I think it is important to integrate new teaching methods throughout the classrooms, so that students don't get bored and PBL is one of them."

Correspondingly to PA Teacher 20,

> "In today's technology era, innovative tools is important to use in the classrooms and teachers need to be updated with these new tools, and using projects in the class promotes innovativeness and promotes different materials to use in the class."

In summary, all the teachers portrayed how PBL can be beneficial and important in the students' learning experience. All teachers agreed that the main advantages of project-based learning was collaboration and creativity. These two factors can aid students in all aspects of their academic and later career life. Hungarian and Palestinian teachers also expressed that developing self-confidence from presenting projects in class is beneficial. Most Hungarian teachers articulated that PBL is an innovative teaching method and how important it is to present new methods and techniques when it comes to teaching to enhance the student's learning experience, while the Palestinian teachers did not reflect that PBL is an innovative teaching method. The Palestinian teachers were not too keen on PBL as an innovative teaching method. The last advantage that most teachers brushed upon was in-depth learning, half of the Hungarian and Palestinian teachers did not discuss it as an advantage, while the others stated that PBL allows students to be more involved with a topic by experiencing it with a hands-on activity such as projects. To sum up, all teachers have displayed their perspectives on the advantages of implementing and applying a project-based learning approach in their classrooms.

Research Question 3: Educators reveal common challenges in the implementation of STEAM education.

Hammond and Jackson (2015) depict the importance of culturally applicable pedagogy in shifting the paradigm from a traditional teaching model to one that focuses on students' strengths. Therefore, the shift to implement STEAM education presents a few challenges and during the interviews, teachers have expressed the difficulties they potentially face. These challenges include knowledge and practice for implementing STEAM, the allocation of time, limited access to resources, lack of professional development, and others. The table below demonstrates the themes that emerged from the teachers' views regarding obstacles teachers face when trying to implement STEAM education.

Theme 1	Time Management
Theme 2	Students' Abilities
Theme 3	Curriculum Integration
Theme 4	Limited Resources
Theme 5	Preparation of Lessons and Materials
Theme 6	Assessments
Theme 7	Limited Training/Knowledge

Table 13: Themes from RQ3

Time Management

Teachers often recognize the value of using art-based methods in their lessons, but with any positive aspects, there could be challenges when trying to implement art methods in the class. Starting with time management, most of the teachers have implied the restricted time constraint they face in the classroom when teaching a subject, they have a specific time limit to complete a lesson and have mentioned how that itself is not always enough, so when adding an extra task or involving a new method can take more time from the lesson goals. Therefore, when adding a new tool or method in the classroom it requires careful planning and allocation of class time. Art projects often demand more time than traditional lessons, and this can pose a challenge for teachers who need to cover a broad range of subjects within a limited time frame.

> "I usually have 50 minutes to teach a class, so yes I do find that I am restricted when it comes to time, sometimes when I am giving a lesson I can't even go through all of it because time isn't enough, so I can't imagine adding an art project or activity in the class everyday or every other day because it does take time" (HU Teacher 3).

> "I can barely juggle finishing a full 45 minute lesson, let alone adding art activities in the class, so that's why if I decide to do a project it would be once every two weeks or something like that, because really it takes a lot of time and effort to add it to the lesson" (PA Teacher 15).

> "I applaud teachers who are able to complete their lesson plans in the time they are given, but for me I tend to find it difficult to complete a full lesson because there is too much to discuss and I do not have enough time to go over everything, I wish I had a longer class so I can implement different methods and activities in the class, but unfortunately it is hard and I can't always do it" (HU Teacher 9).

> "I need to make every minute count in the class, so sometimes adding an activity or even a group activity takes time, until I put the students in a group they move, I need to explain the activity, that itself takes 20 minutes or so and already almost half my time is gone, so trying to balance the constraints of a packed curriculum with the idea to incorporate art into it presents me with a bit of a challenge" (PA Teacher 17).

Moreover, teachers have expressed how challenging it could be to integrate art into the classroom due to time constraints especially when they are trying to keep up with the lessons in the curriculum. Another challenge with limitation in time for art activities is that it often poses open-ended questions and ideas which allows students to explore and create at their own pace. This approach is important and can aid in their creativity, but is a time-consuming process. Therefore, teachers must try to create a balance between giving students the freedom to express themselves and ensuring that the learning objectives are met within the available class time.

> "Art activities can be very time consuming especially when students are being creative and innovative, so it takes more time than just listening to a lesson and answering questions" (PA Teacher 22).

> "The challenge of time management for us teachers when doing an art activity is trying to find the right balance between encouraging creativity and covering core academic content" (HU Teacher 7).

Additionally, gathering and organizing art supplies, setting up workstations, and providing guidance and feedback to each student throughout the creative process can be time-consuming.

> "I feel that when I make group activities it takes time to put students into the groups, taking the time to explain the activity and taking time to go through each group and give feedback" (PA Teacher 19).

> "I constantly feel pressured in finishing the lesson so whenever I try to do something fun or different it takes more time and effort and I can barely finish any of my lesson objectives, I would have no problem to do more activities if I have more class time than 50 minutes" (HU Teacher 10).

Ultimately, time management in art education is a skill that teachers must continually improve to ensure that creativity thrives in the classroom without compromising the scope of the \curriculum. Teachers in the end do find the lesson time to be restricted and do not have time to add an art activity in the lesson.

Students' Abilities

One challenge teachers can face in the classroom when trying to implement art is the contrasting skill levels and comfort zones among the students. Not all students feel confident or comfortable in their artistic abilities, which can lead to self-doubt and a lack of enthusiasm to participate in art-related activities.

> "As a teacher, sometimes I feel unmotivated to incorporate art activities because I feel that some students may find it boring or they're not interested in participating in the activity" (HU Teacher 10).
>
> Similarly, "While I have students in the classroom who enjoy drawing and partaking in these activities, there are always a few who do not enjoy it and don't seem to put effort into trying to delve into the activity, that makes it frustrating to me as a teacher and makes me not want to do another activity like this" (PA Teacher 23).
>
> "Sometimes I also find it difficult to try and see what each students enjoys when it comes to art, also it hard to make them artistic and see their abilities in it. I know art has its benefits as I mentioned before, but finding their abilities through it is challenging and time consuming" (PA Teacher 22).

Teachers should try addressing this challenge because art activities can establish a supportive and inclusive learning environment. Teachers must acknowledge and respect the diverse skill levels of their students, guaranteeing that no one feels judged or discouraged. Therefore, teachers should encourage their students and create a safe environment for them to feel they are accepted no matter their abilities.

> "I mean yes as a teacher is my I mean our job to enhance and develop students' abilities in the classroom, I should provide specific tools for specific students who need help in certain areas" (HU Teacher 6).

> "It is important to cater students' abilities in the classroom. Yes, of course it is challenging when you have like 26 students in the classroom and only me or 1 teacher, so maybe by doing an art activity it can give me the chance to see their abilities and see what students are good at or need help in" (PA Teacher 17).

> "Of course there's a challenge to try and accommodate the student's learning abilities because one I don't have much time in the class, two I might not know how to help in a specific field, and three I feel students don't always put that much of an effort into an art activity. So yes, that is an obstacle I face in my teaching" (HU Teacher 9).

Overall, while the challenge of having different students' abilities doing an art activity in the classroom is real, it can be addressed through a nurturing and inclusive approach. With the right support and encouragement, students can overcome their reservations and develop a deeper appreciation for the creative process.

Curriculum Integration

Integrating art into the curriculum presents a notable challenge for teachers as they do not have much input in developing the curriculum. Teachers must accomplish and finish the lessons from the curriculum during the school year and that can leave teachers feeling pressured to cover all the topics and details. Thus, adding a new method or tool to the curriculum can be challenging and teachers might not have the authority to do so, so if they want to integrate art into the lesson they do it on their merit. Many teachers have expressed how they don't have much input when it comes to curriculum development or changing topics in it.

> "I can't really add anything to the curriculum because the curriculum comes from the government, so we teachers cannot really change anything, only if the government changed something in it, we can only add like in our lessons, but not physically changing the curriculum" (HU Teacher 2).

> "Yes, as a teacher I guess I can't change anything about the curriculum because it is already set, I am just supposed to follow it and try to finish it by the end of the school year" (PA Teacher 14).

> "As a teacher, I feel too much pressure to be involved in the development of the curriculum because I don't have experience or that I am qualified to do that, so when I think about adding arts in the curriculum, I just think adding it to the classroom is easier than trying to integrate in the curriculum" (PA Teacher 17).

> "So I cannot really change anything the curriculum because the ministry or the government controls that aspect, they just give it to the schools and we must follow it and try to complete the lesson in it until the end of the year, but I mean yes we can add art into lessons in our lesson plans" (HU Teacher 5).

To address this challenge, teachers should find ways to balance the inclusion of art with other academic priorities. This can involve creative scheduling, interdisciplinary lesson planning, and collaboration with other colleagues to integrate art seamlessly into the existing curriculum. Teachers should come together to try and integrate the arts into the lessons and try to promote its benefits for the students.

> "I do agree that the arts can benefit students as I said before, and it should be integrated into the curriculum, but it is hard when you don't have the power to do so, but the least we can do as teachers is trying to use different and new teaching methods into lessons and one of those is art-based methods" (PA Teacher 19).

> "I think its important to involve teachers when it comes to curriculum development, but unfortunately we are not because the curriculum is already set for us, but I do highly recommend adding the arts into the curriculum, not just us teachers adding to the classroom by ourselves, it should be in curriculums so teachers and students get used to using arts in their daily lessons" (HU Teacher 7).

Finally, curriculum development is difficult for teachers to do because it is out of their hands, but see the benefits of implementing arts into their lessons. Recognizing these benefits of art education nurtures well-rounded, innovative, and engaged students in their classrooms. Teachers should find ways to overcome these obstacles and make space for art in the educational realm.

Limited Resources

Teachers often face limitations in terms of funding, time, and access to art supplies or specialized technology needed for STEAM activities. Limited resources are a significant challenge when it comes to implementing art-based methods in education and is particularly prominent in today's educational landscape. For instance, a study by the National Art Education Association (NAEA, 2014) found that budget cuts and resource limitations are major hurdles for art education

in K-12 schools in the United States. These constraints can affect the quality of education for students and teachers begin to struggle to provide students with an innovative learning experience (NAEA, 2014).

> "As a teacher, yes I sometimes suffer from a lack of resources especially if I need new materials for an art project, so then I cannot do the activity with them" (HU Teacher 6).
>
> "Limited resources in art education presents a challenge for us teachers because if I want to do a fun art activity with my students, my school doesn't have enough resources for all of them, so sometimes I need to ask the students to bring some supplies for the activity, and I need to let them know in advance, so it can be a bit frustrating" (PA Teacher 23).
>
> "I'd say yes sometimes I find I am limited in resources for an art activity because there are budgets for the school so I want to do many activities but I am limited because I cannot use all the resources in the school, some of it needs to be saved for other teachers" (HU Teacher 5).

Furthermore, another challenge presented mostly by the Palestinian schools that I saw as the main difference is the use of digital tools. Both Hungarian schools have digital tools set in the classrooms, they each have projectors and smart whiteboards. In the Palestinian schools, none of those tools existed in the classrooms, some classes had projectors while others did not. If a class did not have a projector they had to borrow one from another classroom, and there were no smart whiteboards in any of the Palestinian schools, only in a lab class at one of the Palestinian schools. This resource discrepancy can contribute to gaps in the quality of education and opportunities for students to develop skills relevant to modern experiences, especially in the technology field.

> "I wish the school had a bigger budget to even include technology tools in the classroom, but unfortunately it doesn't. I wish I can use different tools to enhance a student's learning experience" (PA Teacher 14).
>
> "I think with today's modern advances it is important to include technology tools, but yes there isn't a budget to add these tools, and this school is very old so the building is old and sometimes adding new wires or technology doesn't always work, so yea I need to sometimes borrow a projector from another classroom" (HU Teacher 10).
>
> "I teach in the old building, so there aren't any technology tools to use, but if you go to the new elementary school building they would have projectors and smart boards, but here in the high school it's very rare to have, but it is a limitation because today is all about technology and there are so many tools than can help the students and develop their learning experience in the classroom, and using technology can be fun for them since they are always using it all the time now a days" (PA Teacher 18).

In conclusion, teachers face the difficulties of limited resources in the classroom to try and implement art activities from supplies to technology tools. Addressing these confines is crucial to ensure that all students have access to the benefits of art-filled learning to connect their learning with creativity, critical and problem-solving skills, and innovativeness in STEM subjects.

Preparation of Lessons and Materials

Preparing lessons and materials that incorporate art into the curriculum or lesson can be a challenging attempt for teachers. One major challenge is the need for creativity and resourcefulness in designing lessons that engage students while meeting educational goals. Integrating art effectively requires not only subject knowledge but also a deep understanding of how to use different artistic components to enhance students' learning. Therefore, this challenge can be increased for a teacher who may not have formal art training or are less confident in their artistic abilities.

> "For me I'd agree that preparing lesson and materials is a real challenge when including art into lessons because as a math teacher I do not have much experience in this area so it is hard to incorporate into my lessons with little knowledge and maybe it won't even benefit the students" (PA Teacher 17).
>
> "Yes, of course there so many challenges when trying to implement a new teaching method and that includes art. It could be hard meshing art into lessons without the proper guidance and tools to do so" (HU Teacher 6).
>
> "I think for me is finding the stability between a structured course and a bit more of freedom for the students to learn, I do want students to feel like the art is just some way to pass the time away when there are benefits to use art in the lessons, so finding this balance is a challenge" (PA Teacher 15).
>
> "I already find being innovative and creative a challenge to teach in the class so adding art into my lessons is even harder for me because then I would have to find better and more different teaching methods to explore the student's creativity" (HU Teacher 8).

All these teachers have expressed difficulty in adding art into lessons due to not obtaining much information or tactics to use art in the classes. One main difference the research found between the Hungarian and Palestinian teachers was finding the proper materials for art activity. Some materials

can be difficult to come across in the Palestinian areas due to different circumstances while in Budapest, teachers have more accessibility to certain tools and supplies for activities they need.

> "I sometimes have a hard time even finding certain materials or supplies for a project I want to do in the class, and if I ask the students to bring something they also might not be able to find" (PA Teacher 19).

> "I guess it is easy to find any art supplies I need at like different school supply store, like Pirex or Office Depot, so I feel I don't have a problem finding different materials that I need when I want to do an art activity, or if students need to get something they can find it in many different stores" (HU Teacher 7).

> "If I can't find a certain art supply or if I ask students to get and can't find, it's not like we can order online and be shipped to us because with the situation it is hard to do, so then I would have to change the project in order to do with the materials already available at the stores" (PA Teacher 23).

Overcoming these challenges can take time, but for starters, teachers could get collaborate with other teachers to share ideas and resources to develop their lessons. Adapting lessons over time and learning from the successes and setbacks of previous experiences can help teachers refine their approaches to integrating art into their curricula. By addressing these challenges, teachers can provide students with an enriching learning experience.

Assessment and Evaluation

Assessing students' learning through art-based methods can be more complicated than traditional assessments. Teachers need to develop effective evaluation tools to measure the impact of art-based methods in STEM subjects. This challenge to create assessments that adequately evaluate students is tough and tricky because teachers will look at a student's creativity. Therefore, teachers should assess students in an all-inclusive and qualitative approach, such as portfolios, presentations, or even self-assessments. These can align better with the nature of art-based learning and provide a more comprehensive understanding of student achievement.

> "From a teacher's viewpoint, assessing and evaluating students when art is integrated into lessons is hard because there is not always a right or wrong answer when it comes to student's creativity, each student is different and there isn't anything wrong with that, but finding assessments that cater to this can be hard" (HU Teacher 9).

> "Giving tests or quizzes is like the easiest option to grade students, so when you need to grade an art activity that is a true challenge, so as teachers we need to find the proper assessment tools to grade students which is based on my things, starting off with participating or engagement in the activity" (PA Teacher 22).

> "I mean grading a science test is easy because there are one answer to questions so when trying to grade a science project involving art is a bit tough, I need to find an assessment that best suits the project, so I sometimes find a rubric where students need to follow and it acts like a guide, but in the end is a better choice to assess students or not? I am not entirely sure, so I guess I focus more on the standard way of grading" (HU Teacher 3).

These quotes reflect the challenges teachers face when assessing students in integrated art lessons. Unlike subjects with clear right or wrong answers, creativity makes grading difficult. Teachers must find the proper assessment tools that accommodate individual differences and the open-ended nature of artistic expression. While traditional tests provide an easy grading method, they may not effectively evaluate art activities. Some teachers use rubrics as guides, but determining the most appropriate assessment method remains uncertain. Balancing standard grading practices with the unique demands of art integration presents an ongoing challenge for educators.

> "As a math teacher, having tests is the easiest and most straightforward way of grading student's understanding of the lesson. How would I know if they understood the lesson from a project or activity if no grades isn't involved, I don't find it as a fair way to grade them" (PA Teacher 17).

> "I mean as a teacher we should develop our skills and find new ways to evaluate students, but when you have no prior knowledge to do it then it is hard to do it, but I would like to learn new ways to assess students that might be better than the standardized test or quizzes" (HU Teacher 4).

In summary, teachers have found it difficult to find different and effective ways to assess students from the standard method of tests or quizzes. Teachers need to learn new ways that could help students who aren't the best at taking tests so they have a better chance to show they understand the subject. Therefore, to effectively measure student learning and the impact of art-based activities, educators must learn to design assessment strategies that encompass both artistic and STEM-related scopes, ensuring that the benefits of creative and interdisciplinary education are sufficiently recognized.

Teacher Training/Development

Educators typically self-select into professional development opportunities to enhance their understanding of different teaching approaches. However, the lack of an organized platform to disseminate information about these opportunities poses a challenge for educators seeking to expand their knowledge in STEAM integration. Moreover, educators often bear the financial and temporal costs associated with attending such professional development activities. Thus, teacher training and development is a vital component for the successful implementation of art-based methods in education. As mentioned previously, art-based methods offer a dynamic and creative approach to teaching, but many teachers may lack the training and confidence to effectively integrate art into their teaching practices. A study by the National Art Education Association (NAEA) emphasizes the need for professional development to prepare educators with the skills and knowledge necessary for using art-based methods. The research highlights that without proper training, teachers may feel ill-prepared to engage students in art activities and effectively link them with STEM subjects.

> "Definitely there are challenges when implementing art into the classroom, so that's why I recommend teacher training or development workshops" (PA Teacher 21).
>
> "Having trainings and development meetings is vital for us teachers because education is always changing and evolving so our teaching methods need to develop, and one new method as you mentioned is using art in the classroom, and for me who hasn't many ideas on how to use it, these trainings can be highly beneficial" (HU Teacher 4).

Similarly,

> "Teachers need to develop with the new teaching culture, so having professional meetings and trainings is important to help students and let them explore new things in their learning experience" (PA Teacher 22).
>
> "In my perspective, teacher training for art in lessons are a call to embrace the role of a mentor and guide, and making our classroom an environment where creativity can be displayed from the students" (HU Teacher 9).

A few teachers also mentioned the importance of teacher development workshops on how they bridge the gap between traditional teaching and creative learning.

> "Teachers have a role in the classroom to develop student's learning and if that means taking training then that's what we should do. Not all teachers have knowledge on how to use art so having training can help us in that aspect and it will make us move away from the traditional ways of teaching" (HU Teacher 6).

The principals have also expressed how they do trainings from time to time for teachers on developing their teaching methods, it doesn't include using art, but it allows teachers to come together and learn from each other.

> "We do teacher professional development meetings monthly for teachers to learn new ways of teaching and for teachers to come together to learn from one another and get different ideas" (PA Principal 13).

> "We sometimes do some teacher training, but we can do more in order to implement art into the classes, because maybe some teachers do not know how to use it, so having these trainings can really aid the teachers and create a fun learning environment for their students" (HU Principal 1).

Lastly,

> "I agree teacher trainings are necessary and important for teachers because you can never stop learning and teachers need to keep up with modern teaching especially using technology, so if it comes to art I know most teachers might not have experience in it so having these trainings can introduce them to this new method and how to use it in the classroom" (PA Teacher 20).

Nevertheless, teacher training and development can connect traditional teaching to new and innovative teaching methods. After the interviews, teachers have expressed the lack of knowledge of integrating art into their lessons so attending and completing training in this regard can highly benefit them and portray a new teaching method to their students to support their learning and depict to them how developing their skills is important.

5.4.4 Student Interviews

In this section, we will delve into the primary themes and expose the discoveries that emerged from the interview process and the subsequent analysis of the data from the student's perspectives regarding art-based methods in STEM education. To start, there is a table providing a concise overview of each participant in Hungary and Palestine. There were a few themes that surfaced after scrutinizing the data concerning the student's opinions regarding art-based methods

in STEM education, beginning with the positive learning impact of art-based methods, freedom of expression, interest in the lesson, memory, and retention, and lastly art-based method challenges. These themes are intricately linked, as the data analysis revealed the positive effects art-based methods have in STEM education. The choice of high school students (9th-12th grade) as participants in the research on STEAM education in Hungary and Palestine was influenced by several concerns. Firstly, high school students are at a critical stage in their educational journey where they are facing important decisions about their future academic and career paths. Investigating the impact of art-based methods on STEM education at this stage allowed the researcher to determine the effectiveness of such methods during this focal period of academic development. Secondly, high school students typically experience a more advanced and specialized curriculum, providing different perspectives on STEAM education. This age group is more likely to have exposure to a diverse range of STEM subjects allowing the researcher to explore the applicability of art-based methods across different scientific disciplines. Thirdly, STEAM education is rarely integrated in high school classrooms, compared to elementary classrooms. The decision to interview 13 Palestinian students and 10 Hungarian students was based on factors such as practical constraints and the availability of participants, where more Palestinian students were asked to be interviewed. All 23 interviews were voice recorded, and the audio file was erased after transcription. Consequently, all these interviews were conducted anonymously. Subsequently, each interview will be recognized by the countries HU- Hungary or PA- Palestine, the interviewee's position- Student; and the interviewee's code number (*e.g.*, HU Student 1, PA Student 1,... and so forth). The interview durations varied, ranging from 20-30 minutes. The specific numbers may also be associated with the principle of capacity in qualitative research, where data collection continues until no new themes or insights emerge, ensuring a comprehensive understanding of the participants' perspectives in each context.

5.4.5 Results

The results section captures the students' perspectives on STEAM education from interviews. Their perceptions, experiences, and attitudes are pertinent to the research inquiry and demonstrate a nuance of insights from the Hungarian and Palestinian students essential to the research. Through meticulous analysis, discernible patterns and insights emerge from the students' narratives which provides a comprehensive understanding of their viewpoints. The table below demonstrates the themes that emerged from the coding process regarding STEAM's learning outcomes and benefits for the students from research question 4. The researcher can compare and contrast coded data across interviews, identify patterns, and draw conclusions regarding the benefits of incorporating art in education from the student's viewpoint.

Theme 1	Engagement
Theme 2	Personal Expression
Theme 3	Critical Thinking
Theme 4	Collaboration and Communication Skills
Theme 5	Emotional Well-being
Theme 6	Interest and Enjoyment
Theme 7	Memory and Retention
Theme 8	Project-Based Learning

Table: Themes from the RQ4- Benefits of STEAM

Engagement

The significance of using art-based methods to enhance students' engagement cannot be overstated. Art serves as a multifaceted tool that transcends traditional educational boundaries, offering a unique path for students to express themselves and be creative. When students encounter art they become active participants in their learning journey. This active involvement raises a deep connection between the learner and the subject matter, making their learning experience more riveting. Many of the students during the interviews have stated how more engaged they feel in the

lesson if they are completing an activity using art-based methods (HU Students 5,6,7, PA Students 12,13,14).

> "I feel more involved with the lesson if I am a part of it so when I do an activity I feel like I am contributing to the lesson more" (HU Student 7).

Similarly,

> "When I am doing an activity in the class, I can automatically feel I am more involved in the lesson and in my learning experience, I feel engaged and motivated to learn" (PA Student 14).
>
> "Sometimes I get really bored in class just listening to the teacher teach, so when we finally can do an activity, I feel excited and happy because I finally can engage in the subject and learn the subject, so I am always hoping for activities in the class" (HU Student 6).
>
> Also, "I really am a creative person so when any type of activity is being done in the class especially with art I get really happy because I feel I can finally feel involved and I can engage in the lesson and share my opinions and ideas with my classmates" (PA Student 13).
>
> "When I don't fully understand a topic, I don't feel like I want to participate in the lesson, but when we do an activity it gives me the confidence to learn and be involved more in the topic, I will want to participate and learn from my teacher and maybe my classmates as well" (HU Student 5).

Lastly, PA Student 19 also expressed a similar perspective on how they want to participate in the lesson when conducting an activity because it gives them the courage to speak their mind.

> "When I am doing a fun activity with art I begin to feel calm because I can participate and share my opinion in the class."

Furthermore, when teachers use art-based methods in the lesson it can provide diverse learning styles, acknowledging students different comprehension skills from visual tools, kinesthetic, and auditory methods. These learning differences guarantee that no student is left behind and the classroom becomes a safe space for students to learn and not be overlooked.

> "I am definitely more of a visual learner, so when I see pictures about the certain topic I am learning for example in my science class it makes me curious and want to learn more about it, I feel the teacher engages me in the lesson when they use tools that help me learn" (HU Student 2).
>
> "Through art, I've learned that there's more than one way to solve a problem, which makes me want to learn and draws me into the subject" (PA Student 12).
>
> "I can see from my classmates that we all learn differently, so for me I am a visual person so when the teacher uses visuals to explain stuff I do become more engaged in the class and it develops my learning" (PA Student 17).

In conclusion, students want to engage in the classroom when they feel drawn to the subject. Art-based activities can help encourage students to participate in the lesson and can accommodate students' learning capabilities. Teachers need to keep this in mind when teaching a lesson, using new methods in the classroom promotes students' engagement.

Personal Expression

Art serves as a powerful instrument for individuals to communicate their thoughts, emotions, and unique perspectives that surpass traditional norms. When students are supported to explore their creativity through artistic activities, they not only develop a deeper understanding of themselves but also obtain a sense of ownership over their learning process. The feeling of self-efficacy in learning involves a confident belief in one's ability to master academic challenges and achieve desired outcomes by having a sense of competence and control over the learning process. Simultaneously, the concept of omnipotence in learning reflects an empowering perception that learners possess the capability to direct and influence their educational experiences comprehensively by emphasizing a proactive and assertive approach to acquiring knowledge and skills. Art allows students to delve into their imagination enabling them to convey ideas that may be challenging to communicate through normal circumstances. From the interviews, many students have stated when applying art activities to the lesson they discovered their strengths and preferences to their learning experience.

> "Art is a safe space for me because it can express myself without any judgement because each one us thinks and feel different so we can have the freedom to express ourselves" (PA Student 23).
>
> "When I am creating art or doing an art activity I feel I can easily express myself without anyone judging me, I can be creative and not worry about being right or wrong" (HU Student 9).

Similarly,

> "When I am creating something through art I can see the beauty of what I am creating and feel free to create whatever I want and however I want. I have the freedom to fully express myself and put my best efforts into the activity" (PA Student 18).

Moreover, a few students voiced how art can bring students together and promote students to express their individuality and celebrate their differences together.

> "I mean each one of us thinks differently and it is okay of course so we shouldn't feel ashamed about that, we should come together and express ourselves, and I think art does that for us" (PA Student 12).
>
> "Expressing myself is very important and art can do that, but what else is important is listening to our classmates and learning about their opinions and through art activities we can do that and not feel judged" (HU Student 3).
>
> "When we do like a science activity that involves art I can see the different perspectives of my classmates and I can find my own personal voice to share to my classmates and teacher" (HU Student 7).

Each student's unique perspective becomes a valuable contribution to the collective learning in the classroom. In conclusion, teachers should emphasize and highlight students' personal expression through art-based methods. Teachers should embrace and encourage personal expression from their students in the classroom.

Critical Thinking

Another theme that came up from the student's interviews is critical thinking; when students create art or explore visual pieces, they are evoked to think critically about the diverse elements from color, shape, or texture. Art prods students to question, challenge, and discover various perspectives. Students have expressed how art makes them think outside the box,

> "Art makes me a critical thinker by pushing me to think about different things and meanings" (HU Student 10).
>
> "I like art because there is not a right answer to something, but makes me thinking of different possibilities or outcomes to a question and yes that can be hard, but with the help of my classmates and teacher I feel I can learn in a new way" (PA Student 15).

Similarly, PA Student 11 posed their perception by conveying,

> "I get really excited when we do like an art activity in a science class because it can challenge me to think and be different from my classmates, I start to think and come up with different ways to learn the topic."

> "Art teaches me that there's more to learn than just drawing or painting, but with more advanced activities I feel I can develop my critical thinking skills because I need to think outside the box of the topic and look deeper into the idea" (HU Student 3).

Lastly,

> "I guess I would say I like solving problems and when I do an activity that challenges me I get excited to learn and makes me think critically and I like to learn with my classmates and see their opinion about the activity too and maybe compare ideas together" (PA Student 12).

Additionally, students expressed how art can articulate their ideas better and how they can show their ideas through the activity.

> "I can explain myself better if I do something with art, and this lets me see different perspectives and can engage my critical thinking skills" (HU Student 8).
>
> "Using art in the classroom can be a safe place where we can learn together and break down hard topics together and I can see what challenges me and try to come up with different ways to explain my ideas" (PA Student 19).
>
> "Art comes in many different ways and that is the same as how we think so art can develop my critical thinking skills by seeing different patterns or pictures or visuals that can make me ask questions and listen to different ideas from my classmates" (HU Student 6).

To end this theme, PA Student 15 explained,

> "Through art activities I've discovered that critical thinking is not just about finding answers; but like about asking deep questions. This makes me want to explore and appreciate different creative ideas."

In conclusion, art-based methods develop critical thinking skills for students. The process of creating art encourages them to question, analyze, and challenge themselves with new information.

Collaboration and Communication Skills

As mentioned above, art provides a unique and powerful road for self-expression, which leads to effective communication and collaboration skills. Firstly, creating art encourages students to speak and portray their thoughts, emotions, and ideas visually. This multisensory approach to expression promotes developing these skills that can aid students in the education and career aspects. Furthermore, engaging in collaborative art projects cultivates interpersonal communication skills. When students engage in group projects or activities with art they are

collectively contributing to a shared learning experience. Therefore, collaboration not only improves their ability to work effectively in a team but also develops interpersonal and communication skills. Many of the students during the interviews have revealed how art can develop their teamwork and communication skills which go hand in hand.

> "I enjoy working in a group with my classmates because I can learn the value of teamwork that can be beneficial not only to my education but for my work in the future" (PA Student 22).
>
> "I think art projects like in science class can really help us on how to work with one another in a group and I know that is very important, also it let's us explain our ideas to our teammates and listen do different point of views" (HU Student 9).

Similarly,

> "I really like working in a team project because it let's me learn how to work in a group especially with classmates I never been in a group with, I can also learn how to communicate my ideas in an understanding way the same for my teammates" (PA Student 20).
>
> "Working in group projects especially with art is a lot of fun, and I can work with my classmates on making something different and cool" (HU Student 1).

Thus, when students come together to work on an art project or activity students learn how to collaborate, compromise, and communicate effectively to their teammates. When students work together they learn to express their perspectives while merging ideas of their classmates. Collaboration parallels with real-world scenarios where effective communication is key to successful teamwork. Students expressed how they felt the freedom to express themselves authentically, trying to develop their self-confidence, and a willingness to share their perspectives on certain issues.

> "When we do group art projects is shows me that communication is not just about expressing my ideas, but also about understanding and listening to the ideas of my group mates" (HU Student 2).
>
> "Through art and projects I've developed the confidence to communicate my thoughts and feelings. I can improve my communication and working together skills to use in my everyday life" (PA Student 16).
>
> "I like using art to express myself, so when we can use it in a group for an activity or project it lets me be creative and share my ideas, but I can also hear the ideas of my classmates and maybe that will make us feel comfortable with each to share if it's supposed to be graded you know {laughs}" (HU Student 9).

Lastly, PA Student 18 stated,

> "Art allows me to communicate without any restrictions by being creative and showing my ideas to my classmates, I also like collabing (collaborating) with my classmates and see what they can make and be creative together."

Consequently, when students collaborate they can create connections, build trust, and learn to appreciate different ideas. This interconnectedness contributes to a positive learning environment. Students who engage in artistic efforts can express themselves creatively, develop interpersonal skills, collaborate, and improve communication skills that are essential for success in academia and beyond.

Emotional Well-being

The integration of art-based methods in education plays a vital role in supporting students' emotional well-being. Art therapy can be an expressive outlet for students allowing them to delve into their emotions in a safe and supportive environment. Students can self-explore their emotions which fosters emotional intelligence and self-awareness. Engaging in art also offers a form of stress relief and relaxation whether through drawing, painting, sculpting, acting, or dancing it can provide a sensory experience that can be calming. Art can offer students a healthy coping method to manage the strains of their education or even personal life. A few students have discussed how art helps them through challenging encounters whether in school or outside of school (HU Students 3,5, PA Students 15, 23).

> "Art is my way of letting go of things that bother me, when I am painting I can let out all my emotions into my picture and this can really help me if I feel stressed from school, it's my favorite hobby, so by adding this to my lessons I think it would want me to learn more" (HU Student 3).

> "As a student, we have every right to feel pressured and struggle with our classes, but when I am dancing I get let go of these aspects and just enjoy what my body can do through dance, I need to remember that my emotional well-being is as important as learning in school" (PA Student 23).

Similarly,

> "I love anything art and art is my creative outlet when I am feeling stressed in school and art can let me focus on relaxing and not stressing so much, I wish though my teachers can added it more into the classroom" (HU Student 5).

The last student describe their opinion by saying,

> "In a group art project, I realized the support art brings to our emotional well-being. It lets us have a shared experience where we can help each other through creative aspects" (PA Student 15).

Moreover, art-based methods encourage a sense of accomplishment and self-esteem. When students watch their creative ideas come to life they experience a tangible demonstration of their capabilities. This influences students to be positive about their self-perception and an increase their confidence and self-worth. When it comes to a classroom setting, the collaborative aspect of art projects promotes the notion of support, a sense of belonging, and connection among each other. Thus, students learn to appreciate the diversity of emotions allowing students to be empathetic and understanding towards each other.

> "Art is my to express myself and maybe for my classmates also, it makes my idea come to life through the project or activity. My group and I can create something different and be confident in what we created" (PA Student 17).

> "I can be a bit shy, but when I feel I am safe and no judgment is shown in my group it allows me to speak my ideas and I feel I can get support from my classmates or when the teacher makes me feel the project is fun and safe I feel happy" (HU Student 2).

> "Art is for everyone is different, but when we are put into a group project we learn how to express ourselves with our classmates so getting their support or even them just listening to my ideas makes me feel good and willing to continue to share, my emotions are not being hurt and I can I guess count on my teammates for help" (PA Student 20).

In essence, the incorporation of art-based methods in education is essential for supporting students' emotional well-being. Again, it provides a means for self-expression, stress relief, and the development of emotional intelligence. Teachers need to develop a positive and supportive environment through art in their classrooms. A teacher's job is not only to their student's academic growth but to their emotional and mental well-being.

Enjoyment and Interest

Art has a unique way to captivate students' attention by presenting dynamic and engaging methods. Students can have a positive learning experience when they are enjoying the lesson and are genuinely interested in the class, for instance when teachers implement fun activities or even activities that include art-based methods. As written above and throughout the research, art creates a space where interest is presented, imaginations are stirred, and a genuine passion for learning. Students can become active participants in the classroom when their interests are peaked which demonstrates enthusiasm and a deeper understanding of the subject leading to lifelong learning. This is connected with Csikszentmihalyi's Flow theory. It explains that when students are engaged in activities that incorporate art, they enter a state of flow, which is a mental state characterized by complete absorption, heightened focus, and a sense of enjoyment. In this state, the challenges of the learning task are balanced with the students' perceived skills by designing the best learning experience. Lastly, Csikszentmihalyi's Flow theory portrays how active participants become interested and enthusiastic about their learning contributing to a lifelong learning experience. In the students' interviews, some students have been informed on how they are more interested in the lesson when different teaching methods are involved instead of the traditional form.

> "I start getting bored when the teacher just keeps talking and talking without doing anything else, I don't feel motivated to learn, but when we do activities I enjoy the class more and I will want to participate" (HU Student 7).
>
> "I don't like just hearing my teacher give a science lesson, I want to be involved in the learning, so when we can do activities or work in groups I appreciate it because it makes me want to learn and I think the subject becomes more interesting" (PA Student 16).
>
> "Today technology is important in education, so I feel teachers should use it in the classroom, because I am always on my phone or my iPad so I think it would be more enjoyable the lesson when we can use technology or even play a game or do an activity that we use technology" (HU Student 10).
>
> "Lessons can be fun when teachers make it fun, so just listening to them explain something doesn't sound too fun, but yea if we do an art activity that can be linked to the subject I would enjoy the lesson more and be willing to participate in the class" (PA Student 19).

The notion that art can cater to diverse learning styles for students has been mentioned and validated and for students when different learning styles become evident in the class they tend to enjoy it more. Students are different and learn differently from visual, kinesthetic, and auditory learners. Using different sensory methods in the classroom ensures that students can connect with the material in ways that resonate with their individual preferences. This type of learning is inclusive and can create a positive learning culture. A few students have portrayed how they have different learning styles and how important it is to be used in the classroom to enjoy their learning experience.

> "When a lesson includes any type of art, it's not just about memorizing facts, but becomes a fun lesson where I am appreciating the subject" (PA Student 23).
>
> "I am a visual person, I like to see things so when the teacher adds different pictures or posters or creates a visual presentation I feel I learn better and become engaged in the lesson" (HU Student 1).

Similarly,

> "Learning in different ways is what makes learning fun, so I enjoy when my science teacher keeps it interesting and fun either by creating interesting presentations, or doing an experiment, or like a group activity" (PA Student 21).

Furthermore, students need to enjoy the lesson and it is the teacher's job to keep the students engaged and interested in the lesson. There are so many new learning styles, techniques, and tools to use in the classroom instead of the traditional way. Students will appreciate it more when teachers create a fun, but an informative lesson. From the interviews, when students find joy and interest in the lesson they begin to engage, develop a deeper understanding of the subject, and grow different skills. So integrating art-based methods into education is not just about boosting enjoyment in the classroom, but establishing a transformative learning experience that promotes creativity, innovation, and enthusiasm to continue learning.

Memory Retention

The last theme that was discovered from the students' interviews is enhanced memory retention of the subject. Art, as mentioned, can engage multiple senses, creating a multisensory learning experience that notably contributes to memory formation. Once students actively participate in artistic activities it stimulates different areas of the brain to promote memory retention. When teachers implement art-based methods in the lesson students are encouraged to learn and this has a positive impact on memory retention. Some examples of art-based methods include the use of visual aids, graphic organizers, diagrams, mind maps, and pictures or sketches. These tools can be potent in the learning process for students and aid in their memory retention of the subject or topic.

> "When the teacher uses different types of art in the lesson it lets me remember things than just listening to the teacher. I feel I get a better impression of what the lesson is about when different teaching styles are used in the classroom" (PA Student 11).
>
> "I have a hard time just memorizing definitions or facts when the teacher speaks, but when I see some visuals like posters or something I feel I will remember the information of the lesson better than not seeing anything" (HU Student 6).
>
> "I think yes when teachers use art in the lesson it can help students remember information because the students will engage in the class more and participate more so that can lead us to remember the information better" (HU Student 5).

Comparably,

> "Art is important and for me I will remember the subject better when the teachers show presentations or we can do something that will let us remember the information, for example maybe playing a game where I am participating in the class, instead of just listening to the teacher teach" (PA Student 22).

Additionally, collaborative art projects in the classroom can contribute to social learning and memory retention. When students are working together they have a hands-on learning experience and promote engagement in the lesson topic. When students engage in discussions or group activity it allows students to express themselves in a unique matter contributing to information remembrance. PA Student 14 has expressed,

> "When I am working on an activity or project, I feel I will remember the topic more because I actually worked on it for a few days or hours, than just listening to the teacher explain it."
>
> "I like doing activities in the class because I can finally do something to remember the information and this will motivate me to keep learning and remember things for the next year when I get to my other grade" (HU Student 1).
>
> "When we do a project it is a group effort and then we can have a space to learn and remember more because we are putting more effort into the project to present properly to the class and get a good grade" (PA Student 15).

Project-Based Learning

A few students have expressed how projects demonstrate their creativity and self-expression. The students found participating in projects useful. One student remarked,

> "I definitely prefer doing projects in the classes because I consider myself very artistic and doing projects it allows me to be creative and show what I can do visually" (HU Student 9).
>
> "By doing projects, I am automatically being creative, and already allows me to cooperate and collaborate with my fellow classmates regarding the topic of the project. Working together is beneficial because it gives me different skills to use in my future and lets me practice how to be part of a team" (PA Student 17).

Furthermore, students felt that by doing projects they become more involved in the lesson and course, and students can learn new skills from their classmates through projects. Starting with HU Student 4,

> "Working in a group is useful because it gives me a lot of skills I can use in the future because when I work I want to be an engineer and I need to practice how to work with other people. So it is important to start now and get used to working with other people. I consider myself a creative person and doing projects lets me be as creative as I can be and I find that very useful and important."
>
> "I personally like doing group projects more than individual projects because it associates using your memory when working in a group with the subject you are learning. I also think it is better than doing a test because projects you can learn more and actually remember what you learned than doing tests. Projects is a good way to learn in my view" (PA Student 16).
>
> "Projects allows me to feel like I am being part of the lesson instead of just sitting and listening to the teacher the whole time. I feel like I learn more not only from the goal of the project, but from my friends and classmates because we are all sharing our ideas through the project" (PA Student 23).

In summary, all the students portrayed how PBL is beneficial and important in their learning experience. In conclusion, integrating art-based methods into lessons significantly enhances

students' memory retention. These multisensory tools create a rich learning environment that promotes deep understanding and lasting memory. Teachers need to find innovative ways for students to have a substantial learning experience.

Challenges of STEAM

As we delved into the positive insights from students garnered from interviews demonstrating STEAM education as a rich and dynamic learning approach, however, it also proposes significant obstacles for learners, as interpreted from the students' interviews. Their insights gave valuable information in understanding their encounters that can enhance the efficacy of implementing STEAM in classrooms. The table portrays the recurring themes that emerged from the interviews that can offer valuable insights for educators, policymakers, and researchers alike on the challenges of STEAM elicited from research question 4.

Theme 1	Fear of Judgment and Failure
Theme 2	Lack of Materials
Theme 3	Lack of Confidence
Theme 4	Difficulty with Art
Theme 5	Insufficient Feedback

Table: Themes from the RQ4- Challenges of STEAM activities

Fear of Judgment and Failure

The first theme that was figured from the students' interviews was the fear of being judged or failing an activity or project dealing with art. As many positives and benefits of art are mentioned throughout the texts, art can allow students to feel they could be judged by their peers and classmates. They may also have the fear of failing because there is not one right answer when conducting an art activity or project. Therefore, students have the fear of not meeting the proper standards of artistic skill or outcomes due to personal ideals or lack of creativity. Many students

have expressed how they fear being judged and failing a certain subject (HU Students 1,6,10, PA Students #14,18,22).

> "Art is a very personal thing because it is how I feel, so when I need to present it or show it to the class I have the fear that I could be judged from my classmates, eventually leading to maybe failing the activity. I get really nervous if I get a bad grade" (SP#1).

Similarly,

> "When I am doing an art activity it means I am expressing myself and not everyone can agree or like what I make so that makes me nervous about being judged or talked about from my classmates or even teacher and maybe she can fail me or something if I didn't do it correctly, I think art is very personal and you need to fully accept yourself" (PA Student 14).
>
> "I really don't like being judged and I feel art can do that because everyone is looking at your work and some people might not like that so they are judging my work, the work that I worked hard on so that makes me nervous and like also what if my teacher doesn't like the work I did, will she give me a bad grade or no that also makes me nervous" (HU Student 6).
>
> "Art 100% self-expression so people no matter what will judge, but it should be constructive not destructive. I feel teachers should tell students to not judge others work and have an open mind about the student's work" (PA Student 22).
>
> "The struggle for me when I do art isn't just about getting a good grade but the fear of my idea not being good enough" (PA Student 18).

Lastly,

> "If I fail or get a bad grade in an art class, it's like just about having a low grade, but it makes me think I am not creative or my idea is stupid. Also, the same feeling I would feel if my classmates didn't like my work" (HU Student 10).

Teachers should try to overcome these challenges in order for students to learn and express themselves in a free and safe space. Teachers should encourage students to be diverse and different, and explain how to not judge other students' creative work. Teachers need to encourage healthy and open mindsets where it is acceptable to think and feel differently leading to imaginativeness. Additionally, teachers need to provide constructive feedback and not just a grade that focuses on growth rather than perfection or a perfect score.

> "Art is the one thing where we can fully express ourselves, but I still have the fear of being judged and makes me self-doubt my abilities" (HU Student 7).
>
> "Art should be a praise different ideas from the students and not feel like we are being judged from our classmates or teachers. I think teachers need to tell this to students that everyone thinks differently and that it is okay to" (PA Student 17).

Furthermore, teachers need to inspire and push students to be divers and help them with these challenges of feeling judged or failing the subject. Teachers need to be inclusive and allow students to express themselves freely to create an environment where they are empowered and can learn.

Lack of Materials

This theme has been more evident in Palestinian schools due to the lack of financial issues in the school or not finding the right materials. Thus, when essential art supplies are scarce students are forced to compromise their vision and creativity due to these limitations. The absence of a variety use of materials hinders their ability to experiment with various methods deterring the development of their artistic skills. This can frustrate the students because they can feel disheartened and demotivated withdrawing their interest in art. Starting with this student,

> "I mean for me I sometimes feel frustrated when we cannot do a certain activity because we don't have enough materials, and I feel less motivated to learn because we are always doing the same thing in class" (PA Student 12).
>
> "Sometimes it is hard to see other schools having more fun in the classroom or doing fun activities and we can't because we don't have the materials and resources to do those activities and my parents sometimes can't afford these materials so I hope the school can" (PA Student 20).

Another student spoke on a similar matter,

> "Sometimes it is discouraging to know we can't do some activities in the class because we do not have enough materials for everyone" (PA Student 13).
>
> "I think it is the school's job to give us the materials and enough materials so we can do activities instead of just listening to the teacher give a class, doing these activities can motivate us to learn more, so I don't know schools should provide us with the materials" (PA Student 11).

Overcoming the challenge of scarce materials requires an intensive effort from the school to allocate these resources effectively for students to explore, innovate, and engage in different artistic activities.

Lack of Confidence

Another challenge students face when using art in the classroom is that they do not feel confident in their artistic abilities. From the students' perspectives, it showed that they get nervous or insecure when presenting their project or activity in front of their classmates. Therefore, overcoming this challenge requires a nurturing and supportive environment where students feel safe to experiment, make mistakes, and embrace their artistic journey. Building confidence in the art classroom is not merely about mastering techniques but promoting a mindset that acknowledges students' creative expression, no matter their current skill level.

> "When we do an art activity in the classroom, I sometimes feel I don't have the enough confidence to create something very nice because I feel I am not that good in art" (PA Student 21).
>
> "I feel I lack the confidence in anything with art which makes me hesitant to put my ideas into the world and let me classmates to see it" (HU Student 5).
>
> "If we are not used to presenting something or showing off our art skills, it makes me less confident to show it to my classmates, I feel I never had teachers to uplift me in my creative thinking and ways" (HU Student 2).

A comparable statement was made by another student who said,

> "I am not the most confident person when I present, so I get shy and nervous, but teachers should make us feel comfortable or even to start presenting and doing different activities from a young age" (PA Student 19).

Ultimately, addressing the challenge of lack of confidence is important and teachers should be encouraged to speak up and be able to present in front of a class. Teachers should start explaining the importance of developing confidence from a young age so they can get used to it, and this can aid them in their future endeavors.

Difficulty with Art

The challenge posed by the difficulty of art projects in the classroom was mentioned by students during the interviews. There are so many methods and uses for art so some students may

find it difficult to complete art projects. Each student has their capabilities so not every student can do an art-based method, each has their preference on what art activity they enjoy doing. This challenge can lead to frustration, self-doubt, and a sense of inadequacy where they are not able to fully immerse themselves in the creative process. Starting with these students, they explain the difficulties they face when they try to do activities that deal with art.

> "To be honest, I am not the best when it comes to art like I enjoy it, but I am not the best and some art methods are difficult to do when I have never done it before" (HU Student 8).
>
> "If I have never done this art method like for example dancing, I will not be able to do this activity because I have never taken it before or have ever done an activity dealing with dance, so to include it in the classroom it can be hard" (PA Student 16).
>
> "I think art is hard because some art activities we do in the classroom are boring, for example I don't like to draw too much, so I prefer maybe doing a different art thing, but if that the only activity we have to do then I don't really enjoy it and I would feel bored in the class" (HU Student 10).

A similar student also expressed how they feel bored in the class when they do an art activity they do not like.

> "Some activities I am not the biggest fan of, so I don't feel like participating in the activity or if it's a group activity I don't want to engage, so I think teachers need to find things were all students can enjoy" (PA Student 19).

Another challenge that can arise from this theme is where students struggle to be creative. Students can find it challenging to break free from traditional norms and be pushed into different learning approaches. Therefore, teachers play a crucial role in this aspect, where they need to ease new approaches slowly and understand the struggle could face when implementing art-based methods into the classroom. Teachers should find different methods that each student feels comfortable associating and completing. A few students have described their feelings toward new activities that deal with art,

> "I don't get how teachers expect us to complete a certain art activity when I have never done something like this before, they don't really explain it too much which becomes frustrating because they assume we already know, when we don't. So I think teachers need to take it easy and explain first what we will do and how it can benefit us" (HU Student 4).

> "We still have some teachers who just teach in the traditional way, so when they tell us to do an activity without any explanation and just assumes we know what to do makes me very confused and question what I need to do, and then it's graded and I am not sure how I can do it properly" (PA Student 16).
>
> "I like to explore new things in the class, but it can be hard and doing an art activity can be hard if we haven't done one in so long, because we don't do many in high school so like being creative is hard and I don't know if I am on the right path or not" (HU Student 3).
>
> "Some art activities can be challenging so teachers need to be patient with us while we try and figure out on how to finish it, so they should watch over us and make sure we are doing it in a correct way" (PA Student 21).

In conclusion, as much as art can benefit students, students can get frustrated and find difficulty in being creative and using different art-based methods in the classroom if teachers do not aid students or create a safe space for them to explore these new methods. Teachers should provide clear and precise instructions about any activity so that students can handle it with precision and confidence. Students should never feel discouraged when new methods are being implemented in the classroom, so teachers need to stand by their students and uplift their spirits.

Insufficient Feedback

The last challenge that students have described is how they do not receive enough feedback from teachers when any type of art is involved. Constructive feedback is crucial in the creative process because it serves as a guide to students to realize their strengths and improve their weaknesses. When there is insufficient feedback students may start feeling uncertain and hesitant about their work. Firstly,

> "When teachers don't provide proper feedback especially in an art activity its like I don't know if I am going in the right direction and I feel like I'm in the dark, its not like an exam when you grade and there are right and wrong answers" (PA Student 15).
>
> "I think it's important to hear back from the teacher to see if we going in the right direction because art comes in different ways, so I'd like to know if my idea is good and if it makes sense since maybe it is harder to grade" (HU Student 6).
>
> "It goes both ways when grading an exam and then grading an art activity, teachers should give us proper and nice feedback over what we created because not everyone does the same and everyone creates different, so how could mine be better than my classmates when we are just self-expressing ourselves, so teachers need to find proper ways to tell us their opinion" (PA Student 22).

Moreover, without meaningful feedback, students may struggle to grasp the different techniques and methods dealing with art-based methods. It affects the overall learning experience for students where they can miss out on opportunities for reflection, dialogue, and constructive critiques that are vital for learning and artistic development. Another student expressed,

> "Art projects without good feedback is like telling me what I did was complete wrong and it is really bad, which would make me think the way I think and feel is wrong" (PA Student 17).
>
> "I think it is important to get a good critique from our teachers so we can practice on what we need to work and makes me see what I should work better on, it makes me reflect my own work and I think that is important to develop my learning" (HU Student 9).

In the end, teachers should actively engage with their students and provide thoughtful and specific feedback that encourages growth. When teachers feedback it promotes questioning and reflection on their work and it portrays to them they are supported, motivated, and empowered to develop their creativity.

5.5 Conclusion and Summary

The conclusions drawn from the interviews conducted with Hungarian and Palestinian students regarding STEAM education reflect different understandings of the role of creativity and interdisciplinary approaches in education within these distinct cultural and educational contexts. Among Hungarian students, there is a discernible appreciation for the integration of art into STEM subjects, with a significant portion agreeing. The interviews unveil a recognition among Hungarian students that art-based methods contribute positively to their learning experiences in science, technology, engineering, and mathematics. This positive learning aligns with broader global trends advocating for a holistic and multidisciplinary approach to education. On the Palestinian part, a parallel appreciation for art-based methods in STEM is evident, with many students strongly agreeing with the integration of arts into traditionally technical subjects. This resonates with the growing acknowledgment of the value of STEAM education, highlighting the interaction between

arts and STEM disciplines. Palestinian students, like their Hungarian counterparts, recognize the potential of art to enhance creativity, critical thinking, and problem-solving skills in the realm of science and technology. However, the interviews also reveal variations in the intensity of agreement between the two groups, potentially influenced by diverse cultural and educational backgrounds. While both regions of students express positive attitudes toward the integration of art into STEM, subtle differences emerge showing societal perceptions of the role of arts in academic settings. The qualitative insights gathered from these interviews display the versatile nature of students' perspectives on art-based methods in STEM subjects. The findings demonstrate the importance of considering cultural diversity and individual experiences in shaping attitudes toward innovative educational approaches.

6. Findings and Conclusions

6.1 Findings and Summary

Chapter 6 concludes the research with the findings, addresses the limitations, and offers recommendations for future practice and research. The section on implications of findings begins with a detailed examination of the analysis results from Chapter 5, aligning them with the main research questions and the theoretical framework established in Chapter 2. Moreover, the discussion on existing literature that portrays the positive use of STEAM education supports the perceptions and insights brought forth by the participants. The limitations section discusses the constraints encountered during the study, providing transparency about its scope and boundaries. Recommendations for future research and practice are made to guide future attempts in exploring STEAM education and these recommendations are informed by insights collected from the study to address gaps and challenges identified. The research delved into teachers' and students' perspectives and opinions regarding STEAM education and it examined their views on its benefits for the student's learning experience, implementation and integration into lessons, and the challenges. The qualitative phase involved in-depth interviews with selected secondary teachers, students, and administrators, conducting a STEAM activity in a science or math class, and observations exhibited valuable insights into STEAM perceptions and challenges. The findings from this dissertation serve as a groundwork for future research endeavors to develop and promote STEAM education practices and policies to enhance learning experiences for all learners in the 21st-century educational landscape.

In recent years, there has been a prominence on preparing students for STEM-related careers and supporting their abilities as creative problem-solvers. Consequently, the shift to

integrating the Arts into STEM disciplines, forming STEAM education, has become widespread because it aims at developing students' creative problem-solving skills, collaboration skills, communication skills, critical thinking skills, and more. While existing studies have explored STEAM implementation, there is a lack of research on the necessary support for schools to implement STEAM. This research discussed a plethora of perspectives from secondary teachers and students in Hungary and Palestine. These perceptions were examined and investigated throughout the research and it strived to contribute to current literature. The chapter provides a combination of the research's findings and discussions, limitations, and conclusions. The research employed a variety of data sources, including STEAM activities, observations field notes, and face-to-face interviews to obtain insights from administrators, teachers, and students. The use of triangulation enabled a comprehensive understanding of the subject matter, with field notes and interviews being the pivotal components in documenting the data. Through meticulous analysis, the researcher's transcription of responses and field notes explored the interpretation of the participants' attitudes and experiences concerning STEAM education. This analytical work required a thorough and precise organization, examination, description, and interpretation of the accumulated data. The research focused on many research questions, with a subsequent section presenting the researcher's interpretations and conclusions associated with the existing literature and theoretical framework.

6.2 Discussion of the Literature Findings

Commencing with prevalent literature regarding the advantages of STEAM education, the literature demonstrates universally the acknowledgement of the numerous benefits of STEAM education for students. Additionally, they recognized STEAM as a student-centered approach highlighting the importance of teaching them the skills necessary for addressing real-world

challenges. The evolving secondary education is slowly transitioning from discipline-specific structures to thematic or conceptual frameworks (NRC, 2011). This transition requires educators to adopt a systemic perspective and foster broad content knowledge. Yet, it is vital for teachers to competently facilitate STEAM-themed curriculum with substantial and ongoing professional development (NRC, 2011). Participants in the study displayed the importance and the adoption of an inquiry-based approach to learning and highlighted the importance of students engaging in real-world problem-solving activities. This perspective is shown in Hoachlander and Yanofsky (2011) explaining that STEAM concepts incorporate a hands-on approach, inquiry-based, real-world, and project-based interdisciplinary programs. Conversely, Wang's (2012) earlier work implies the significance of STEAM by school administrators and educators, however, many secondary teachers lack a comprehensive understanding of how to implement and teach through this approach. Additionally, Lantz (2009) advocates for a transdisciplinary approach by pushing problem-solving, innovation, inventiveness, confidence, and technological literacy. Thus, educators should create opportunities for students to explore their interests collaboratively within a beneficial learning environment. Expanding on this idea, teachers and students have expressed that STEAM education promotes collaboration through team-based tasks and enhances academic merit by conducting hands-on learning experiences, this perspective is seen in literature from Lantz (2009) and STEAM education seeks to improve and stimulate students' skills in innovativeness and creativity (Gettings, 2016; Land, 2013). Other scholarly literature also depicts the development of creative thinking and is a fundamental skill for students in their educational experience (Conradty & Bogner, 2018; Guyotte et al., 2015; Liao, 2016). According to Hartle et al. (2015), the arts assist in cognitive functions where the arts involve both the brain and the body in a unified method of learning. Blanken-Webb (2014) also supports how the arts play a role in shaping cognitive development by connecting emotions leading to empathetic connections and emotional and

interpersonal experiences. Art-based methods present learners with a pathway for expression, communication, and connection through innovative and creative means vital for a successful career (Hartle et al., 2015). Furthermore, Shernoff et al. (2017) further signify the prominence of innovation and creativity in STEAM education. When students participate in STEAM education, students' unique expressive abilities are displayed thereby fostering student engagement (Blanken-Webb, 2014). The participants in this study identified essential components of STEAM education that boost their collective understanding based on an inquiry-based learning approach and meaningful problem-solving. Yakman (2012) delved into student ownership over learning through experiential learning. Additionally, Margot and Kettler (2019) emphasized the student benefits from STEAM's open-ended, student-driven, and problem-solving approaches; these approaches are crucial for nurturing 21st-century competencies and collaborative skills essential for their future careers. STEAM education incorporates creative thinking methodologies, including design thinking. Research reveals when students are engaged in design they display a deeper comprehension of the topic or project (Gess, 2017; Gross & Gross, 2016). The findings displayed the significance of collaborative efforts in understanding and conducting STEAM activities. Kasza and Slater (2017) described the usefulness of teamwork over individuality because teamwork promotes the sharing of meanings and insights relevant to problem-solving tasks. Educators require time, patience, and collaborative support to feel confident in implementing STEAM and fostering student-led learning experiences (Moon, 2020). This statement implies a need for educators to create a culture of teamwork and collaboration to conduct and integrate STEAM education (Holmlund et al., 2018; Radziwill et al., 2015). Sabol (2010) highlighted the unprecedented challenges, opportunities, and potentials faced by individuals in the 21st century by presenting the need for educators to equip learners with essential skills to navigate the evolving technological, occupational, and global landscapes. With advancements in technology and globalization,

educators need to tackle the task of fostering adaptability and initiating problem-solving learners to thrive in an environment characterized by constant change (Winthrop et al., 2017). Thus, educators are entrusted with the responsibility of preparing students to succeed in dynamic 21st-century environments and future professions. Amidst educators' endeavors to support students' capability of applying both subject knowledge and acquired skill sets within a global context, STEAM education has emerged as a practical approach in secondary classrooms to achieve the necessary educational outcomes for the 21st century (Doniger & Sydow, 2016). Overall, STEAM education allows students to learn about relevant topics and engage them through real-world problems, this aligns with the 21st Century Skills and the P21 framework. The teachers and students of this research corresponded with the findings of Oner et al. (2016) on the role of STEAM integration in fostering students' creativity. Additionally, they underlined the importance of instructional approaches using project-based learning opportunities or having science fairs confirming with the literature regarding these pedagogical strategies in helping an effective STEAM integration. Competence in both content knowledge and effective pedagogical strategies significantly influences the efficacy of integrated STEAM instruction (Caprara et al., 2012). This statement is agreed also with Cotabish et al. (2013) displaying the necessity for educators to adopt new trends and teaching methods. However, Dugger (2010) explains that financial constraints can affect teachers to obtain the proper resources for training and implementing in their lessons.

The obstacles to STEAM implementation discussed by the teachers mirror other research discussed previously. Bell (2016) discussed the need for teacher support or training to improve their understanding of STEAM integration which was also discussed during the interviews with the teachers and administrators. Teachers have mentioned the need for professional development opportunities to integrate and approach STEAM education effectively, as depicted in the literature

from Doniger & Sydow, 2016 and Jones et al., 2016. Berlin and White (2012) and Wang (2012) also concur that providing teachers with training and preparation in STEAM can enhance science education by developing inquiry-based and hands-on learning approaches. Another noticeable finding pertains to the challenge of garnering support for resources and tools for STEAM implementation which aligns with existing literature. Vann (2013) also observes the financial restrictions faced by many educational institutions and underscores the importance of ongoing education and experiential learning opportunities to facilitate students' comprehension of STEAM applications.

6.3 Discussion of the Theoretical and Conceptual Framework

A few well-renowned theorists and their theories were discussed throughout the dissertation. The idea that STEAM education focuses on a student-centered approach was first delved into by prominent developmental theorists: Lev Vygotsky, Jean Piaget, and Carol Dweck. The research aims to underscore the implications for instructional design, educational practice, and learner development within the contemporary educational landscape. In the context of STEAM education, Vygotsky's theory underscores the significance of collaborative learning environments where students engage in discussion and problem-solving activities. (Vygotsky, 1978). According to the principles of social constructivism, knowledge construction is a product of social interactions and is shared rather than individually acquired (Lincoln & Guba, 2013). The findings align with this notion, as participants described STEAM education as a collective work (Guba & Lincoln, 1994). Guyotte et al. (2014) elaborate that STEAM practices depend on collaborative efforts among all stakeholders by placing STEAM as a social practice involving teachers, students, administrators, parents, and other participants. Participants conceptualized STEAM education as a socially constructed phenomenon wherein teachers transition from traditional, teacher-centered

approaches to facilitative roles guiding student-centered learning. Within STEAM disciplines, learners are offered opportunities to work in teams, draw upon diverse perspectives, and co-construct knowledge through interaction with classmates. These collaborative activities develop students' communication, teamwork, and critical thinking skills vital in STEAM fields. Similarly, Piaget's constructivist theory demonstrates that learning is an active process of learning knowledge through interaction within a specific environment. In the framework of STEAM education, Piaget's theory draws attention to the importance of a hands-on learning experience enabling students to explore, direct, and investigate real-world issues. When learners learn through inquiry-based approaches, such as project-based learning, students are engaged in life-like scenarios that require the application of disciplinary knowledge and experimentation. Carol Dweck's mindset theory presents the role of beliefs about intelligence and learning in shaping motivation, effort, and achievement. Dweck's theory portrays the importance of fostering a growth mindset because it promotes risk-taking, resilience, experimentation, innovations, and creative problem-solving. The growth mindset theory can be seen through the teachings of STEAM education because STEAM promotes students' learning development through creative and innovative tasks and methods. Therefore, these theorists delved into diverse concepts regarding a student-centered teaching approach that can be seen in modern settings such as STEAM education. Educators can design and implement pedagogical practices that foster collaborative inquiry, authentic engagement, and growth-oriented mindsets, influenced by these theories, and in so doing learners are prepared and equipped with the suitable knowledge and skills for the 21st-century global economy.

6.4 Practical and Policy Implications

Globally, education is changing constantly and different methods and approaches emerge in the classrooms, however, in the contemporary educational discourse, the Partnership for 21st

Century Learning (P21) framework has appeared as an essential guideline for educators and policymakers to prepare learners' skills and competencies required in the 21st-century. This section explains the practical and policy implications of integrating P21's framework of 21st-century skills into STEAM education, clarifying the potential to cultivate a workforce adept at navigating the complexities of a rapidly evolving global landscape. The P21 framework articulates a comprehensive set of interdisciplinary skills, often referred to as the "4C's", *"critical thinking, communication, collaboration, and creativity"*, also obtaining information literacy, media literacy, technology literacy, and life skills. The components of P21's framework can be compared with the principles of STEAM education, in which educators promote P21's skills into STEAM pedagogy. For instance, critical thinking is connected to the inquiry-based approach, a characteristic of STEAM education and demonstrated in the P21 Framework in which students engage in authentic, problem-based learning experiences to analyze, evaluate, and produce information from diverse disciplinary perspectives. Other skills such as communication and collaboration, are two interrelated skills emphasized within P21, and these two skills occur within the collaborative learning environments, a trait also displayed in STEAM education. Project-based learning and interdisciplinary teamwork allow students to improve their ability to articulate ideas effectively by having lively and diverse discussions in a teamwork setting. Additionally, communication skills foster interpersonal competencies, empathy, and cultural proficiency essential for learners in the global context. In addition to the development of the 4C's, P21's framework encompasses information literacy, media literacy, technology literacy, and life skills which are central to learners in this digital age and can be seen when integrating STEAM into classrooms by using different technological tools to enhance a student's learning experience. Thus, when these skills and approaches are integrated into curricula, educators ensure students with the critical skills are responsible for lifelong learning. In terms of a policy perspective, the integration of P21's

Framework into STEAM education highlights the necessity of interdisciplinary approaches to curriculum design, teacher professional development, and educational assessment. Moreover, policymakers and institutions should invest in teacher training, instructional resources, and educational technology to encourage educators to implement different pedagogical practices that connect 21st-century skills within STEAM disciplines. Michael Fullan's Changing Theory also offers insights into the dynamics of learning, cognition, and pedagogy. The Changing Theory explains that learning is a dynamic and repetitive process characterized by constant adaptation and transformation. Learners are actively constructing and reconstructing knowledge through interaction with their environment, classmates, peers, and culture. STEAM education correlates with Fuller's Changing Theory with its nature of inquiry-driven learning experiences, from student exploration, experimentation, and discovery and connecting it to real-life instances. Moreover, the integration of the arts within STEAM curricula offers opportunities for creative expression, exploration, and imaginative play paralleling Fuller's emphasis on the role of emotion, creativity, and embodiment in learning. One practical association of integrating Fuller's Changing Theory into STEAM education promotes student agency, independence, and ownership in their learning environments. Moreover, with the notion of collaboration and feedback, educators empower students to co-construct knowledge, challenge one another, and explore multiple perspectives. In conclusion, the correlation of P21's Framework of 21st-century skills and Michael Fullan's Changing Theory with STEAM education holds profound practical and policy implications for promoting an experience equipped with the proper knowledge, skills, and tools vital for success in the 21st century. Educators should strive to improve students' critical thinking, communication, collaboration, and creativity alongside technology literacy, and life skills within STEAM learning environments. Educators and policymakers can empower students to thrive and be innovative in an increasingly interconnected and complex world.

The qualitative analysis displayed a common perspective among both Hungarian and Palestinian teachers and students, where they acknowledged the essential value of STEAM education and its impact on developing a learner's skills. Conversely, participants indicated challenges and a need to change and aid teachers in implementing an effective STEAM initiative in classrooms. As pointed out from responses to the Interview Question, which explored the insights into the primary challenges confronting STEAM education in terms of time management, lack of resources, and professional development, reiterates what the Change Theory emphasizes regarding change-oriented perspectives when shaping a new teaching method-STEAM- in curriculum implementation. In addition, the Framework for the 21st Century portrays, as mentioned previously, essential skills such as critical thinking, creativity, innovation, and problem-solving to be successful in the global setting. The qualitative analysis reinforced what the Framework for the 21st Century states especially during the interviews in response to Questions, clarifying participants' perspectives on STEAM education and the skills learners can achieve once STEAM is successfully implemented in the classroom that align with the goals of the 21st Century Skills Framework. The four main C's the Framework demonstrates are relevant and echoed by the participants emphasizing the importance of creativity, critical thinking, communication, and collaboration in developing a student's skills. These skills ensure students' readiness for post-education interests and career efforts. The findings draw attention to embracing a change in educational settings to support the principles the 21st Century Skills Framework brought forth to reinforce the efficiency and continual STEAM education initiatives.

6.5 STEAM Activity and Observation

The aim of conducting the STEAM activity and observations was to investigate the similarities and differences in student engagement and collaborative efforts in creating a STEAM

project within a math and science class context. When comparing the experiences of Hungarian and Palestinian students during the STEAM activities, several notable differences and similarities emerged. Hungarian students seemed to have access to more technological resources and educational infrastructure compared to Palestinian students, potentially influencing their technical proficiency and problem-solving abilities. Palestinian students face socio-political challenges and resource constraints that impact their access to educational opportunities and extracurricular activities. Hungarian students engaged in STEAM activities conducted in their native language, facilitating clear communication and comprehension of instructional materials. Palestinian students, whose primary language may vary (*e.g.*, Arabic, English), may encounter language barriers that impact their understanding of STEAM concepts and instructions. Hungarian students, generally residing in more affluent and stable socio-economic environments, may have greater access to educational resources and extracurricular opportunities that support their STEAM learning experiences. Palestinian students, facing economic hardships and political instability, may exhibit greater resilience and adaptability in navigating challenges encountered during STEAM activities. The findings revealed similarities in the levels of engagement and collaboration among students from both Hungary and Palestine by displaying enthusiasm and cooperation throughout the STEAM activity. Additionally, students seamlessly integrated prior knowledge and concepts from mathematics and science to create their geometric or green city and displayed a comprehensive understanding of the STEAM activity. The collaborative nature of the STEAM activity encouraged students to express their creativity through artistic elements incorporated into their projects and created diverse perspectives on the same activity. As stated by Guyotte et al. (2015), the concept of collaboration when students engage with one another engagement is a better way of learning than doing it individually. During the activities, Hungarian and Palestinian students demonstrated their ability to be creative and innovative. Liliawati et al (2018) express how STEAM

education encourages learners to be unconventional and to be creative thinkers. Educators should embrace and promote creative expression within their classrooms because it provides opportunities for students to explore unconventional solutions and use their imagination. Another key element that promotes and impacts creativity is the formative feedback from educators (Calavia et al., 2021). The perception of feedback originated in many fields and Skinner, an American psychologist, introduced the notion of "procedural teaching", emphasizing the significance of immediate feedback for students by promptly correcting their responses (Rinvolucri, 1994). Subsequently, educators need to provide students with feedback information to facilitate improvement, adjustment, or reconstruction of their knowledge frameworks (Winne & Butler, 1994). Feedback to students during the instructional process is an influential factor in their learning journey and establishes effective learning (Hattie & Timperley, 2007; Hattie, 2008) (Shen et al., 2021). In summary, while Hungarian and Palestinian students may face distinct challenges and opportunities within the STEAM learning context, their shared experiences underline essential skills such as fostering critical thinking, collaboration, creativity, and innovation skills.

6.6 Semi-Structured Interviews

STEAM education has gained significant attention globally for its potential to foster critical thinking, creativity, and innovation among students. Understanding the perspectives of both teachers and students from diverse cultural and educational backgrounds is essential for informing effective STEAM pedagogy and practice. Semi-structured interviews were conducted with Hungarian and Palestinian teachers and students to explore their perspectives on STEAM education. The interviews focused on themes such as the perceived importance of STEAM, challenges and barriers to STEAM implementation, and strategies for enhancing STEAM learning experiences. Thematic analysis was employed to identify common themes and divergent

perspectives across the participant groups. The participants' insights portrayed STEAM to be interdisciplinary and highlighted STEAM's learning outcomes for students from its practicality, engagement, and collaborative features demonstrated in the 21st-century skills. They also expressed how STEAM promotes motivation to learn different concepts through problem-solving and critical thinking. These qualitative findings coincide with existing literature, supporting STEAM's effectiveness in developing students' learning skills by conducting effective efficacy in hands-on, project-based learning activities, as mentioned in research from Christensen, Knezek, and Wood (2015) and Brouillette and Graham (2016).

Hungarian teachers emphasized the significance of STEAM education in preparing students for future careers and highlighted the importance of hands-on learning experiences and interdisciplinary approaches in fostering students' problem-solving skills and creativity. Palestinian teachers expressed the transformative potential of STEAM education and how it fosters innovation and empowers students to become critical thinkers and instruments of change in their communities. Despite contextual differences, both Hungarian and Palestinian teachers recognized the value of STEAM education in preparing students for the demands of 21st-century skills. They highlighted the importance of fostering creativity, critical thinking, and collaboration through hands-on, inquiry-based learning experiences. Policymakers and educators should prioritize equitable access to resources and professional development opportunities to support effective STEAM implementation across diverse educational settings. Moreover, fostering partnerships between schools, universities, and community organizations can enhance STEAM learning experiences and promote inclusive participation among students from marginalized backgrounds. Hungarian students demonstrated a keen interest in STEAM education, viewing it as an avenue for exploring their creativity, problem-solving abilities, and future career prospects. They highlighted

the significance of hands-on learning experiences and collaborative projects in fostering their engagement and enthusiasm. However, both students and teachers acknowledged challenges such as limited access to resources and the need for more professional development opportunities to effectively implement STEAM initiatives. Moreover, Hungarian students expressed enthusiasm for STEAM activities, citing opportunities for collaboration, experimentation, and real-world application of theoretical concepts. Palestinian students expressed similar enthusiasm for STEAM education, recognizing its potential to empower their skills in critical thinking, creativity, and problem-solving. However, they also identified barriers such as infrastructure limitations and lack of resources, which hindered equitable access to STEAM opportunities. The qualitative and quantitative data gathered to explore the third research question, about the perceptions of teachers and administrators regarding the support and sustainability of STEAM programs in their educational institutions, yielded pertinent insights into the relationship between these two cohorts. To elucidate how qualitative findings complemented quantitative results, the researcher conducted in-depth interviews with participants, posing probing inquiries such as delineating the requisite skills for students within an efficacious STEAM program, strategies for administrative backing and perpetuation of such programs, and identification of potential lacunae within the current STEAM framework. Collectively, responses to the research question- regarding the challenges teachers face when attempting to implement STEAM- teachers underscored the need for training and resources. These findings from the teachers are supported by studies, such as a study by Quigley and Herro (2017), their study displayed the need for professional development opportunities for teachers and should be a pivotal step toward enhancing educators' understanding and implementation of STEAM. The research conducted by Boice, Jackson, Alemdar, Rao, Grossman, and Usselman (2021) and by Mastrorilli, Harnett, and Zhu (2014) also demonstrates the need for teacher training when implementing STEAM in the classroom. Moreover, the study conducted by O'Leary and

Thompson (2019) depicts the need for a comprehensive and interdisciplinary educational framework incorporating the arts to promote students' creativity and cognitive development and parallels the findings from teachers and students during the qualitative analysis. Therefore, the qualitative analysis demonstrated a shared understanding and appreciation for STEAM's pedagogical advantages. The overarching conclusion proposes a perceived need for STEAM education and its imperativeness to bridge existing gaps and enhance the efficacy of STEAM initiatives in educational settings.

6.7 Limitations

This study offered and demonstrated insights into educators' perspectives on STEAM integration in secondary educational settings, however, several limitations constrain the validity and applicability of its findings. Predominantly, the research was limited to five schools within two countries, thereby limiting the extent to which the findings can be inferred to broader educational contexts. Sampling limitations constituted another notable constraint, primarily stemming from the restricted number of participating schools within the district. The geographical context added another layer of complexity by conducting interviews in Hungary introduced the potential language barrier, as not all teachers and students may have English as their first language. This raised concerns about accurate transcription and understanding of their answers which could compromise the integrity of the data collected. Another challenge that arose when trying to find schools in Hungary, is the lack of acceptance from schools to conduct my research. That is why I was only able to attend two schools in Hungary instead of three like in Palestine. It was easier to secure access to the schools and conduct the research in Palestine as I was a former teacher in Palestine, so schools already knew who I was and conducted my research at a previous school where I was employed. Another limitation that was displayed while conducting research was engaging with

interviewees, particularly students aged 14-18 in both regions. The willingness of participants to share their opinions and be recorded emerged as a potential limitation where some students were not fully comfortable participating in interviews or having their perspectives recorded, adding a layer of complexity to data collection, also some students had a hard time expressing themselves or could not give an in-depth perspective regarding the questions being asked. Furthermore, the wide scope of STEAM education, spanning from kindergarten to adulthood, imposed a focus on a specific age group. This strategy introduced the potential for bias in understanding STEAM education because the perceptions of this selected group may not fully capture the broader challenges and opportunities presented by STEAM. Another hurdle displayed throughout the research was school closures due to COVID-19. The global COVID-19 pandemic and its associated factors influenced the outcomes of the research. The research revolved around participants in educational settings, and with the pandemic, the participants' views could have hindered their perceptions of STEAM education within their classroom contexts. Furthermore, differences in interview length introduced limitations to the depth of understanding acquired from participant responses. The researcher made efforts to conduct comprehensive interviews, some interviews ranged from 25 to 40 minutes in duration, however, shorter interviews as brief as 15 minutes, impaired the thorough exploration of participants' perceptions of STEAM education. Nevertheless, despite these limitations, the data analysis process produced valuable insights beneficial to the research's objectives.

6.8 Recommendations for Future Research

The dissertation's findings can recommend future educators, administrators, and stakeholders to allocate both time and financial resources toward implementing diverse professional development initiatives for educators to integrate STEAM. Armknecht (2015)

displays STEAM effectiveness from well-trained educators and administrators through inquiry-based teaching that aligns with the conceptual framework for 21st-century learning. The Teaching and Learning International Survey (TALIS) conducted by the Organization for Economic Cooperation and Development (OECD) in 2009 illustrated a positive connection between professional development and teachers' self-efficacy. Another recommendation is to propose a curriculum that integrates technology, arts-based methods, 21st-century learning frameworks, interdisciplinary skills, and creativity under the context of Change Theory. Therefore, implementing STEAM in secondary schools, and funding for proper materials and tools are necessary to create STEAM projects, facilitate collaborative time for educators, develop STEAM curricula, and provide interdisciplinary professional development opportunities. Stansbury (2011) highlights the importance of having available resources to implement STEAM programs. The adoption of new instructional practices needs training and support to enhance teachers' self-efficacy in differing teaching methods (Gess, 2017; Margot & Kettler, 2019; Stein & Muzzin, 2018). DeJarnett's (2018) case study depicts the positive impact of professional development and support on teachers' self-assurance in STEAM implementation. Schools must detect and modify their environments by considering both the local environment and available resources. Similarly, awareness of external resources and professional connections enhances the real-world relevance of school activities. Future research could explore students' perceptions of STEAM education in broader and global contexts. These research endeavors could entail conducting investigations into the perceptions of STEAM across diverse school districts in various cities and countries to understand the diverse perspectives of people from a geographical, cultural, or political viewpoint. This study, while insightful, focused on examining the perceptions of STEAM education among participants from only five schools in two different countries so the sample size did not fully represent all secondary schools in their districts, thereby constraining the generalizability of the

findings. Therefore, future research should strive to encompass a more diverse selection of participants to provide a broader and more profound understanding of the research questions. To further enhance this research, expanding the study to incorporate parents of the students or various stakeholders' perceptions of STEAM would enrich the research methodology by incorporating controlled observations, polls, and comparative analyses between different participant groups. This would create a comprehensive exploration of the benefits and challenges associated with STEAM education. Moreover, to enhance the thesis' findings, the researcher proposes conducting multiple mixed-method studies across diverse regions nationwide, thus, developing authentic results by incorporating input from educators and administrators with varied experiences and expertise to train secondary teachers to implement STEAM education in their curricula. Rolling (2016) portrays the significance of a collective culture to obtain shared understandings and common STEAM goals. As well, Holmuld et al. (2018) support a collaborative, reflective, and iterative culture to implement STEAM education among educators.

6.9 Conclusion

A qualitative approach was utilized and the findings of this research revealed that both Hungarian and Palestinian teachers and students shared similar perceptions regarding STEAM through qualitative interviews, STEAM activities, and observation. Despite an awareness of the importance of STEAM education, teachers and administrators may not always grasp its full scope. Participants in the study interpreted STEAM education differently based on their experiences, education level, and background knowledge, yet exhibited similar understandings of its meaning, significance, and associated challenges. Other research and studies demonstrated positive and effective implementation of STEAM in classroom settings from primary to university. The findings, implications, and recommendations from this study contribute to ongoing efforts to

enhance perceptions of STEAM education. In summary, the perspectives from both Hungary and Palestine unite in acknowledging the transformative potential of STEAM education. The emphasis on skill development ranging from creativity and communication to collaboration, critical thinking, and real-world application assists as proof- of the effectiveness of integrating art into STEM pedagogy. The thesis delved into the workings of integrating the arts into STEM and switching the paradigm to STEAM. The many benefits of incorporating the arts into education were displayed during this study. Beginning with creativity, a foundation of artistic expression emerges as a powerful influence that allows students to approach problems and tasks in diverse and unconventional ways. It grants them the freedom to explore their unique perspectives and it develops an environment of individuality and innovativeness. Teachers should encourage students to express themselves artistically when the educational paradigm shifts from a passive attainment of information to an active, participatory experience. The arts provide a platform for self-discovery and self-expression allowing students to communicate their ideas with certainty. Collaboration and cooperation are essential skills in the ever-evolving landscape of the 21st century in education and careers and the arts become an integral part of the classroom to develop those skills. Students engaged in shared creative endeavors where they learned to view and accept diverse perspectives and work collectively towards a common goal. The collaborative aspect infused through artistic expression lays a foundation for effective teamwork, a skillset that excels in academic domains and is relevant in real-world scenarios. The integration of the arts into STEM education sparked critical and problem-solving thinking skills. The challenges presented by artistic efforts prompt students to think analytically showing resilience and adaptability. Artistic exploration encourages a mindset where problems are viewed as opportunities for growth contributing to their development in real-life contexts. The research demonstrated the perspectives and insights of high school teachers and students in Palestine and Hungary. This research showed a comprehensive understanding of the

different ways in which the arts can enhance education across diverse cultural and educational contexts by examining the experiences of students and educators in these different settings. In other words, the research aimed to paint a picture This research aspires to contribute to the ongoing dialogue surrounding STEM and STEAM education and seeks to challenge preconceived notions about it. The research insists on a shift in the mindset about the integral role of the arts in the educational landscape by emphasizing the numerous benefits that the arts bring to STEM education. As well, this research is trying to bridge the gap between disciplines and foster a more complex and inclusive approach to learning. The findings of this study not only add depth to the academic discourse but also carry implications for educational policies and practices that advocate for an enriched curriculum that acknowledges and celebrates the arts in STEM subjects. Moreover, integrating STEAM programs in secondary schools has the potential to positively impact education by providing students with essential tools to address global challenges.

References

AAUP. (2021). AAUP LAUNCHES THE ACTIVITIES OF THE SECOND CYCLE OF "STEAM PALESTINE". https://www.aaup.edu/News/aaup-launches-activities-second-cycle-%E2%80%9Csteam-palestine%E2%80%9D

Abed, O., H (2016). Drama-Based Science Teaching and Its Effect on Students Understanding of Scientific Concepts and Their Attitudes Towards Science Learning. *International Education Studies, 9*(10), 163–173. https://doi.org/10.5539/ies.v9n10p163

Adams, E. (2010). The Joys and Challenges of Semi-structured Interviewing. *Community Practitioner, 83*(7) https://link.gale.com/apps/doc/A229720174/HRCA?u=anon~75a1dc04&sid=googleScholar&xid=e4c4e8e3

Adams, K. (2005). The Sources of Innovation and Creativity. *National Center on Education and the Economy (NJ1)*. 1-59.

Al-Balushi, S. M., & Al-Aamri, S. S. (2014). The effect of environmental science projects on students' environmental knowledge and science attitudes. *International Research in Geographical & Environmental Education, 23*(3), 213-227.

Aldemir, J., & Kermani, H. (2016): Integrated STEM curriculum: improving educational outcomes for Head Start children. *Early Child Development and Care.* https://doi: 10.1080/03004430.2016.1185102

Allen, M. (2017). *Participant observation*. The Saga Encyclopedia of Communication Research Methods Encyclopedia Sage Publications https://dx.doi.org/10.4135/9781483381411.n412.

Allina, B. (2018). The development of STEAM educational policy to promote student creativity and social empowerment. *Arts Education Policy Review, 119*(2), 77–87.

Al Nayzak Organization for Supportive Education & Scientific Innovation (R.A). 2021. Retrieved from https://www.alnayzak.org/page.php?id=230f1y143601Y230f1

Andiliou, A., & Murphy, P. K. (2010). Examining Variations among Researchers' and Teachers' Conceptualizations of Creativity: A Review and Synthesis of Contemporary Research. *Educational Research Review, 5*, 201-219. https://doi.org/10.1016/j.edurev.2010.07.003

Anisimova, T., Kalimullina, O., Sabirova, F., & Shatunova, O. (2019). STEAM as an innovative educational technology. *Journal of Social Studies Education Research, 10*(2). https://files.eric.ed.gov/fulltext/EJ1220702.pdf

Anthony, C. J., & Ogg, J. (2019). Executive function, learning-related behaviors, and science growth from kindergarten to fourth grade. *Journal of Educational Psychology.* https://doi:10.1037/edu0000447

Armknecht , M. P. (2015). *Case Study on the Efficacy of an Elementary STEAM Laboratory School* [Doctoral Dissertation] https://digitalcommons.lindenwood.edu/dissertations/316

Barniskis, S. C. (2014). *STEAM: Science and Art Meet in Rural Library Makerspaces* [IConference].

Becker, H. S., & Geer, B. (1970). *Participant observation and interviewing: A comparison. In W. J. Filstead (Ed.), Qualitative methodology: Firsthand involvement with the social world* (pp. 133–142). Chicago: Markham.

Bell, D. (2016). The reality of STEM education, design and technology teachers' perceptions: a phenomenographic study. *International Journal of Technology and Design Education, 26*(1), 61–79. https://doi:10.1007/s10798-015-9300-9

Berlin, D. F., & White, A. L. (2012). A longitudinal look at attitudes and perceptions related to the integration of mathematics, science, and technology education. *School Science and Mathematics, 112*(1), 20–30.

Bertrand, M. G. (2019). *STEAM Education in Ontario, Canada: A Case Study on the Curriculum and Instructional Models of Four K-8 STEAM Programs* [Dissertation]. https://ir.lib.uwo.ca/etd/6137

Bequette, J. W., & Bequette, M. B. (2012). A place for ART and DESIGN education in the STEM conversation. *Art Education, 65*(2), 40-47. Retrieved from http://search.proquest.com/docview/935210962?accountid=458

Blaken-Webb, J. (2014). The difference differentiation makes: Extending Eisner's account. *Educational Theory, 64*(1), 55–74.

Boal, A. (1985). *Theatre of the Oppressed*. Theatre Communications Group, New York.

Bogdan, R. C., & Biklen, S. K. (2006). *Qualitative research in education: An introduction to theory and methods* (4th ed.). Allyn and Bacon.

Boice, K. L., Jackson, J. R., Alemdar, M., Rao, A. E., Grossman, S., & Usselman, M. (2021). Supporting Teachers on Their STEAM Journey: A Collaborative STEAM Teacher Training Program. *Education Sciences, 11*(3), 105. https://doi.org/10.3390/educsci11030105

Boy, G. A. (2013, January 29). *From STEM to STEAM: Toward a human-centered education, creativity & learning thinking.* [31st European Conference on Cognitive Ergonomics]. https://dl.acm.org/citation.cfm?id=2501907&picked=prox

Boytchev, P., & Boytcheva, S. (2020, January 6). *Gamified Evaluation in STEAM* [. International Conference on Information and Software Technologies]. Springer: Berlin, Germany. 369–382.

Brinkmann S. (2018). The grieving animal: Grief as a foundational emotion. *Theory & Psychology, 28*, 193–207.

Brinkmann S., & Kvale S. (2015). *InterViews: Learning the craft of qualitative research interviewing*. Thousand Oaks, CA: Sage.

Brophy, S., Klein, S., Portsmore, M., & Rogers, C. (2008). Advancing engineering education in P–12 classrooms. *Journal of Engineering Education, 97*(3), 369–387.

Brouillette, L., & Graham, N. J. (2016). Using arts integration to make science learning memorable in the upper elementary grades: A quasi-experimental study. *Journal for Learning through the Arts, 12*(1).

Bush, S. B., Cox, R., & Cook, K. L. (2016). A Critical Focus on the M in STEAM. *Teaching Children Mathematics, 23*(2), 110–114

Calavia, M. B., Blanco, T., & Casas, R. (2021). Fostering creativity as a problem-solving competence through design: think-create-learn, a tool for teachers. *Think. Skills Creat. 39* https://doi: 10.1016/j.tsc.2020.100761

Callahan, I. S. (2019). *Project luminous: An e-textiles workshop study to increase science technology engineering mathematics/science technology engineering art mathematics interest in middle school girls.* [Master's Thesis, University of Arkansas]. https://scholarworks.uark.edu/etd

Camargo, C., Brancali˜a, L., Lima, J., Ramos, M., Fernandes, L., Trovisco, M., & Conde, M. (2020). *Emídio Garcia School Pilot description: A Robosteam Erasmus+ project activity based on a challenge based learning approach* [IEEE Global Engineering Education Conference (EDUCON)]. https://doi.org/10.1109/EDUCON45650.2020.91

Caprara, G., Barbaranelli, C., Steca, P., & Malone, P. (2006). Teachers' self-efficacy beliefs as determinants of job satisfaction and students' academic achievement: A study at the school level. *Journal of School Psychology, 44*, 473–490.

Catchen, R. D., & DeCristofano, C. (2015). What's Wrong with Interpretive Dance? Embracing the Promise of Integrating the Arts into STEM Learning. *The STEAM Journal, 2*(1). https://doi: 10.5642/steam.20150201.9

Chang, Y. S., & Chou, C. H. (2020). Integrating Artificial Intelligence into STEAM Education. *Communications in Computer and Information Science, 1227*. 469–474.

Chatman, E. A. (1992). *The information world of retired women*. Westport, CT: Greenwood Press.

Chen, C. C., & Huang, P. H. (2020). The effects of STEAM-based mobile learning on learning achievement and cognitive load. *Interactive Learning Environments.* 1-17 https://doi.org/10.1080/10494820.2020.1761838

Choi, G. Y., & Behm-Morawitz, E. (2017). Giving a new makeover to STEAM: Establishing YouTube beauty gurus as digital literacy educators through messages and effects on viewers. *Computers in Human Behavior, 73*, 80–91. https://doi.org/10.1016/j.chb.2017.03.034

Christensen, R., Knezek, G., & Tyler-Wood, T. (2015). Alignment of Hands-on STEM Engagement Activities with Positive STEM Dispositions in Secondary School Students. *J Sci Educ Technol, 24*, 898–909. https://doi.org/10.1007/s10956-015-9572-6

Chung, C. C., Huang, S. L., Cheng, Y. M., & Lou, S. J. (2022). Using an iSTEAM project-based learning model for technology senior high school students: Design, development, and evaluation. *International Journal of Technology and Design Education, 32*(2). https://doi.org/10.1007/s10798-020- 09643-5

Clapp, E. P., & Jimenez, R. L. (2016). Implementing STEAM in maker-centered learning. *Psychology of Aesthetics, Creativity, and the Arts, 10*(4), 481–491. https://doi.org/10.1037/aca0000066

Cogswell, J., K.M, & McLauchlan, D., L (2014). Explorations with affective engagement: Combining process drama with the Canadian history curriculum. *Applied Theatre Research, 2*(1), 61-75.

Cohen, L., & Manion, L. (2000). *Research methods in education* (5th ed.,p.254). Routledge.

Cohen, L., Manion, L., & Morison, K. (2007). *Research Methods in Education* (6th ed.). London: Routledge.

Colucci-Gray, L., Burnard, P., Gray, D. S., & Cooke, C. F. (2017). STEAM - Science, Technology, Engineering, and Mathematics with Arts. In P. Thomson (Ed.), *Oxford Encyclopedia of Research in Education*. Oxford.

Committee on a Conceptual Framework for New K-12 Science Education Standards. (2013).14-18.

Connelly, G. (2012). Art puts the STEAM in STEM. *Principal*, *92*(2), 48.

Connor, A. M., Karmokar, S., & Whittington, C. (2015). From STEM to STEAM: Strategies for Enhancing Engineering & Technology Education. *International Journal of Engineering Pedagogy (iJEP), 5*(2), pp. 37–47. https://doi.org/10.3991/ijep.v5i2.4458

Conradty, C., & Bogner, F. X. (2018). From STEM to STEAM: How to monitor creativity. *Creativity Research Journal, 30*(3), 233–240. https://doi: 10.1080/10400419.2018.1488195

Cook, DJ., Mulrow, CD., & Haynes, RB. (1997). Systematic reviews: Synthesis of Best Evidence for Clinical Decisions. *Ann Intern Med.,126*(5). 376-80. https://doi:10.7326/0003-4819-126-5-199703010-00006

Corbi, A., & Burgos, D. (2017). Open distribution of virtual containers as a key framework for open educational resources and STEAM subjects. *Electronic Journal of eLearning*, *15*(2), 126–136.

Costantino, T. (2018). STEAM by another name: Transdisciplinary practice in art and design education. *Arts Education Policy Review, 119*(2), 100-106. https://doi: 10.1080/10632913.2017.1292973

Cotabish, A., Dailey, D,. Robinson, A., & Hughes, G. (2013). The Effects of a STEM intervention on elementary students' science knowledge and skills. *School Science and Mathematics, 113*(5), 215- 226. https://eric.ed.gov/?id=EJ1011103

Creswell, J. W. (2013). *Qualitative Inquiry and Research Design: Choosing among five Approaches* (3rd ed.). London, England: Sage.

Creswell, J. W., & Miller, D. L. (2000). Determining Validity in Qualitative Inquiry. *Theory into Practice*, *39*(3), 124.

Csapó, B., Fejes, J., Balázs, K., & László, T. E. (2014): Evolution of school performance in Hungary in International Comparison. *In: Kolosi Tamás & Tóth István György: Társadalmi Riport/Social Report*. TÁRKI, Budapest. 110–136.

Csikszentmihalyi, M. (1990). *The Domain of Creativity: Theories of creativity*. Newbury Park, CA: SAGE Publications, 190-212.

Cziboly, A., Lyngstad, M. B.; & Zheng, S. (2021). Influence of the 'conventions approach' on higher education in drama. *Drama Australia Journal, 45*(2), 128-143. https://doi: 10.1080/14452294.2021.2004752

Darling-Hammond, L. (2010). *The Flat World and Education: How America's commitment to equity will determine our future*. New York: Teacher's College Press.

DeBoer, G., Carman, E., & Lazzaro, C. (2010). *The Role of Language Arts in a Successful STEM Education Program*. Retrieved from: https://files.eric.ed.gov/fulltext/ED563458.pdf

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior.* Berlin: Springer Science & Business Media. https://doi.org/10.1007/978-1-4899-2271-7

DeJarnett, N. K. (2018). Early childhood STEAM: Reflections from a year of STEAM initiatives implemented in a high-needs primary school. *Education, 139*(2), 96–110. https://www.ingentaconnect.com/contentone/prin/ed/2018/00000139/00000002/art00006

Dejonckheere, P. J. N., De Wit, N., Van de Keere, K. & Vervaet, S. (2016). Exploring the classroom: Teaching science in early childhood. *International Electronic Journal of Elementary Education, 8*(4), 537–558. https://doi.org/10.12973/eu-jer.5.3.149

Delaney, M. (2014). Schools shift from STEM to STEAM. Edtech, pages 1–4. [online]. Available from: http://www.edtechmagazine.com/k12/article/2014/04/schools-shift-stemsteam

Deloitte. (2015). Tech trends 2015: The fusion of business and IT. http://www2.deloitte.com/au/en/pages/technology/articles/tech-trends-2015.html

Demirel, I. N. (2011). *Köy ve Kent Okullarında Öğrenim Gören Ilköğretim ii. Kademe Öğrencilerinin Görsel Sanatlar Dersine Ilişkin Tutumlarının Karşılaştırılması.* [Master's Thesis]. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=QnBCYu2ZcY46bkC4oIqHRg&no=wLkNjuGsujKDUGk14O2cpg

DeMunck, Victor C. & Sobo, Elisa J. (Eds) (1998). *Using methods in the field: a practical introduction and casebook*. Walnut Creek, CA: AltaMira Press.

DesPortes, K., Spells, M., & DiSalvo, B. (2016). *The MoveLab: Developing congruence between students' self-concepts and computing. Proceedings of the 47th ACM Technical Symposium on Computing Science Education, March 02–05, 2016, pp. 267–272*

DeWalt, Kathleen M. & DeWalt, Billie R. (2002). *Participant observation: a guide for fieldworker*s. Walnut Creek, CA: AltaMira Press

Díaz, B. F., & Hernández R., G. (2002). Constructivismo y Aprendizaje significativo. In Estrategias docentes para un aprendizaje significativo. Una interpretación constructivista (p. 465). Retrieved from http://mapas.eafit.edu.co/rid=1K28441NZ-1W3H2N9-19H/Estrategias docentes paraun-aprendizaje-significativo.pdf

Digital Craft Lab. Retrieved from https://digitalcraftlab.mome.hu/

Donar, A. (2011). Thinking Design and Pedagogy: An Examination of Five Canadian Post-Secondary Courses in Design Thinking. *The Canadian Review of Art Education,38*(1), 84–102.

Doniger, H. T.; Sydow, L. (2016). A Journey from STEM to STEAM: A Middle School Case Study. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*. https://doi: 10.1080/00098655.2016.1170461

Dorion, K. R. (2009). Science through Drama: A Multiple Case Exploration of the Characteristics of Drama Activities Used in Secondary Science Lessons. *International Journal of Science Education*, 31(16), 2247-2270.

Doyle, M. (2017). Elements of Art. *The STEAM Journal*, 3(1) https://doi.org/10.5642/steam.20170301.17

Draper, C. L., & Wood, S. (2017). From Stumble to STEM: One School's Journey to Explore STEM with its Youngest Students. *Exchange, 39*(233). http://0search.ebscohost.com.edlis.ied.edu.hk/login.aspx?direct=true&db=ehh&AN=120822040&site=eds-live&scope=site&groupid=Test

Dugger, W. (2010). *Evolution of STEM in the United States* [In Technology Education Research Conference]. Queensland.

Dunning, B. (2013). Can we be clear on something? It's STEM, not STEAM. Retrieved from https:// www.skepticblog.org/2013/03/14/stem-not-steam/

Dweck, C. S. (2008). *Mindset: The New Psychology of Success*. Random House USA Inc. Creativity and your brain Retrieved from http://www.abc.net.au/radionational/programs/allinthemind/creativity-andyour-brain/9758846

Edwards, D. (2010). *Artscience: Creativity in the Post-Google Generation*. Cambridge, Massachusetts: Harvard University Press.

Ejiwale, J. A. (2012). Facilitating teaching and learning across STEM fields. *Journal of STEM Education: Innovations and Research, 13*(3), 87-94.

Engelman, S., Magerko, B., McKlin, T., Miller, M., Edwards, D., & Freeman, J. (2017). *Creativity in Authentic STEAM Education with EarSketch*. [In Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education. ACM] 183–188.

Elizabeth Buckley School (2018). What is a STEAM school? Retrieved from http://steamschool.ca/about/steam-programs/

Erlandson, D. A., Harris, E. L., Skipper, B., & Allen, S. D. (1993). *Doing naturalistic inquiry: A guide to methods.* Newbury Park, CA: Sage Publications.

Feldman, A. (2015). Why we need to put the arts into STEM education. Retrieved March 1, 2021, from http://www.slate.com/articles/technology/future_tense/2015/06/steam_vs_stem_why_we_need_to_put_the_arts_into_stem_education.html

Ferreira, V. S. (2014). Arts and tricks of comprehensive interview. *Saúde e Sociedade*, *23*(3). https://doi.org/10.1590/S0104-12902014000300020

Floerke, G. (2021). *Amplifying the "A" in STEAM Education* [Honors College Theses, Murray State University]. https://digitalcommons.murraystate.edu/honorstheses/110

Freeman, G. D., Sullivan, K., & Fulton, C. (2003). Effects of creative drama on Self-concept, social skills, and problem behavior. *Journal of Educational Research, 96*(3),131–138. https://doi.org/10.1080/00220670309598801

Fredricks, J. A., Blumenfeld , P. C., & Paris , A. H. (2004). School Engagement: Potential of the Concept, State of the Evidence. *Review of Educational Research*, *74*(1), 59-109. http://www.jstor.org/stable/3516061

Friedlaender, D., Burns, D., Lewis-Charp, H., Cook-Harvey, C., & Darling-Hammond, L. (2014). *Student-centered schools: closing the opportunity gap*. Stanford, CA: Stanford Center for Opportunity Policy in Education (SCOPE). Retrieved from https://edpolicy.stanford.edu/projects/633

Fullan, M. (2007). *The New Meaning of Educational Change* (4th ed.). New York: Teachers College.

Gadsden, V. L. (2008). The Arts and Education: Knowledge Generation, Pedagogy, and the Discourse of Learning. *Review of Research in Education, 32*, 29-61. http://dx.doi.org/10.3102/0091732X07309691

Gardner, H. (1983). *Frames of Mind: The Theory of Multiple Intelligences*. New York, NY: Basic Books.

Gardner, H. (2011). *Creating Minds: An Anatomy of Creativity Seen Through the Lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Ghandi*; Basic Books: New York, NY, USA.

Ge, X., Ifenhaler, D., & Spector, J. M. (2015). *Emerging Technologies for STEAM Education: Full STEAM ahead*. New York: Springer.

Gess, A. H. (2017). STEAM education: Separating fact from fiction. *Technology and Engineering Teacher*, *77*(3), 39-41

Gettings, M. (2016). Putting it all together: STEAM, PBL, Scientific Method, and the Studio Habits of Mind. *Art Education, 69*(4), 10–11. https://doi.org/10.1080/00043125.2016.1176472

Ghanbari, S. (2014). *Integration of the arts in STEM: A collective case study of two interdisciplinary university programs* [Doctoral Dissertation, University of California, San Diego.].

Ghanbari, S. (2015). Learning across disciplines: A collective case study of two university programs that integrate the Arts with STEM. *International Journal Of Education & The Arts, 16*(7).

Glaser, B. (1965). The Constant Comparative Method of Qualitative Analysis. *Social Problems, 12*, 436-445. https://doi.org/10.2307/798843

Glass, D., & Wilson, C. (2016). The Art and Science of Looking: Collaboratively learning our way to improved STEAM integration. *Art Education, 69*(6), 8–14.

Glăveanu, V. P. (2011). How are we creative together? Comparing socio cognitive and sociocultural answers. *Theory and Psychology, 21*(4), 473-492. https://doi:10.1177/0959354310372152

Gordon Gyori, J. (2020a). Shadow education – opportunity for development. *European Journal of Education, 55*(3), 305–310.

Gorman, G. E., & Clayton, P. (2005). *Qualitative Research for the Information- A Practical Handbook*. Cambridge University Press.

Graham, N. J., & Brouillette, L. (2016). Using Arts Integration to Make Science Learning Memorable in the Upper Elementary Grades: A Quasi-Experimental Study. *Journal for Learning Through the Arts*, *12*(1), 1-17. https://files.eric.ed.gov/fulltext/EJ1125147.pdf

Grant, M. M. (2011). Learning, beliefs, and products: Students' perspectives with project-based learning. *Interdisciplinary Journal of Problem-Based Learning, 5*(2), 37–69.

Grinnell, S., & Angal, S. (2016). Luminous lighting. *Science and Children, 53*(6), 54.

Gross, K., & Gross, S. (2016). TRANSFORMATION: Constructivism, Design Thinking, and Elementary STEAM. *Art Education, 69*(6), 36-43. https://doi.org/10.1080/00043125.2016.1224869

Guba, E. G., & Lincoln, Y. S. (1994). *Competing paradigms in qualitative research*. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (p. 105–117). Sage Publications, Inc.

Gulliksen, M. S. (2016). Embodied Making, Creative Cognition, and Memory. *FORMakademisk, 9*(1). https://doi.org/10.7577/formakademisk.1487

Guskey, T. (2002). Professional development and teacher change. Teachers and teaching: theory and practice. *Scientific Research. An Academic Publisher, 8*(3/4), 381-391. http://dx.doi.org/10.1080/135406002100000512

Guyotte, K. W., Sochacka, N. W., Costantino, T. E., Walther, J., & Kellam, N. (2014). Steam as social practice: Cultivating creativity in transdisciplinary spaces. *Art Education, 67*(6), 12–19.

Guyotte, K. W., Sochacka, N. W., Costantino, T. E., Kellam, N., Kellam, N. N., & Walther, J. (2015). Collaborative creativity in STEAM: Narratives of art education students' experiences in transdisciplinary spaces. *International Journal of Education & the Arts, 16* (15). http://www.ijea.org/v16n15/.

Hammond, Z., & Jackson, Y. (2015). *Culturally responsive teaching and the brain: promoting authentic engagement and rigor among culturally and linguistically diverse students.* Thousand Oaks, California, Corwin, a SAGE company.

Han, H., & Lee, H. (2012). A Study on the Teachers' Perceptions and Needs of STEAM Education. *Journal of Learner-Centered Curriculum and Instruction, 12*(3), 573–603.

Hattie, J. (2008). *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement*. New York, NY: Routledge.

Hattie, J., & Timperley H. (2007). The power of feedback. *Rev Educ Res. 77*, 81–112. https://doi: 10.3102/003465430298487

Hattie, J. (2012). *Visible Learning for Teachers: Maximising Impact on Learning*. New York: Routledge.

Hartle, L. C., Pinciotti, P., & Gorton, R.G. (2015). ArtsIN: Arts integration and infusion framework. *Early Childhood Education, 43,* 289–298. https://doi.org/10.1007/s10643- 014-0636-7

Hayman, S. (2017). *Investigating STEAM: Integrating Art and STEM to Spark Innovation* [Doctoral dissertation, University of Kansas, Fayetteville]. ScholarWorks@UARK. https://scholarworks.uark.edu/cieduht/16

Heathcote, D., & Herbert, P. (1985). A drama of learning: Mantle of the expert. *Theory Into Practice, 24*(3), 173–180. https://doi.org/10.1080/00405848509543169

Henriksen, D., Mehta, R., & Mehta, S. (2019). STEAM Education: Theory and Practice: Chapter 4 Design Thinking Gives STEAM to Teaching: *A Framework That Breaks Disciplinary Boundaries*. Springer Nature Switzerland AG. Vol 1. 57-78. https://doi.org/10.1007/978-3-030-04003-1

Heppner, P. P., Kivlighan D. M., & Wampold B. E. (1999). *Research design in counseling* (2nd ed.). Belmont, CA: Brooks/Cole.

Herro, D., & Quigley, C. (2016): Exploring Teachers' Perceptions of STEAM Teaching Through Professional Development: Implications for Teacher Educators. *Professional Development in Education.* https://doi:10.1080/19415257.2016.1205507

Herro, D., & Quigley, C. (2016). STEAM enacted: A case study of a middle school teacher implementing STEAM instructional practices. *The Journal of Computers in Mathematics and Science Teaching, 35*(4), 319.

Herro, D., Quigley, C., Andrews, J., & Delacruz, G. (2017). Co-Measure: Developing an assessment for student collaboration in STEAM activities. *International Journal of STEM Education, 4*(1), 26.

Hill, C. E., Knox, S., Thompson, B. J., Williams, E. N., Hess, S. A., & Ladany, N. (2005). *Consensual Qualitative Research: An Update*. College of Education Faculty Research and Publications. 18. https://epublications.marquette.edu/edu_fac/18

Hill, C. E., Thompson, B. J., & Williams, E. N. (1997). A Guide to Conducting Consensual Qualitative Research. *The Counseling Psychologist*, *25*(4), 517-572. https://doi.org/10.1177/0011000097254001

Hoachlander, G., & Yanofsky, D. (2011). Making STEM Real: By Infusing Core Academics with Rigorous Real-World Work, Linked Learning Pathways Prepare Students for Both College and Career. *Educational Leadership, 68*, 60-65.

Hoadley, C., & Cox, C. (2009). Chapter 2: What is design knowledge and how do we teach it? In *Educating learning technology designers*. (pp. 19-33). Guide.

Holmlund, T. D., Lesseig, K., & Slavit, D. (2018). Making sense of "STEM education" in K–12 contexts. *International Journal of STEM Education, 5*(32). https://doi.org/10.1186/s40594-018-0127-2

Hopia, A. I., & Fooladi, E. C. (2019). *A Pinch of Culinary Science: Boiling an Egg Inside Out and Other Kitchen Tales*. Boca Raton, FL: CRC Press.

Howard, L.W., Tang, T.L.-P., & Austin, M.J. (2015). Teaching critical thinking skills: Ability, motivation, intervention, and the Pygmalion effect. *Journal of Business Ethics, 128*, 133-147.

Hug, D., Petralito, S., Hauser, S., Lamprou, A., Repenning, A., Bertschinger, D., Stüber, N., & Cslovjecsek, M. (2017a, August 23-26). *Exploring computational music thinking in a workshop setting with primary and secondary school children* [Proceedings of AM '17, London, United Kingdom]. https://doi.org/10.1145/3123514.3123515

Hug, D., Petralito, S., Hauser, S., Lamprou, A., Repenning, A., Bertschinger, D., Stüber, N., & Cslovjecsek, M. (2017b). *Exploring computational music thinking in a workshop setting with primary and secondary school children* [ACM International Conference Proceeding Series]. https://doi.org/10.1145/3123514.3123515

Huser, J. (2020). STEAM and the role of the arts in STEM. State Education Agency Directors of *Arts Education.* https://www.nationalartsstandards.org/sites/default/files/SEADAE-STEAMWHITEPAPER-2020.pdf

Ilter, I. (2014). A study on the efficacy of project-based learning approach on social studies education: Conceptual achievement and academic motivation. *Educational Research and Reviews, 9*(15), 487–497. https://doi.org/10.5897/ERR2014.1777

İşyar, Ö. Ö., & Akay, C. (2017). The use of Drama in Education in Primary Schools from the Viewpoint of the Classroom Teachers: A Mixed Method Research. *Online Submission*, *8*(28), 201-216.

Jamalian, A. (2018). How to start a STEAM program in your school. *White paper. Little Bits*. Retrieved from https://www.eschoolnews.com /files/2018/06 /STEMProgramWhitepaper-v2.pdf

Jesionkowska, J., Wild, F., & Deval, Y. (2020). Active learning augmented reality for steam education—a case study. *Education Sciences, 10*(8), 1–15. https://doi.org/10.3390/educsci10080198

Jolly, A. (2016). *STEM by design: Strategies and activities for grades 4–8.* New York: Routledge.

Jones, B. D., Tendhar, C., & Paretti, M. C. (2016). The effects of students' course perceptions on their domain identification, motivational beliefs, and goals. *Journal of Career Development, 43*(5), 383-397. doi:10.1177/0894845315603821

Kampylis, P., & Berki, E. (2014). Nurturing Creative Thinking. International Academy of Education, UNESCO, 6. In Retrieved from http://unesdoc.unesco.org/images/0022/002276/227680e.pdf.

Kant, J., Burckhard, S., & Meyers, R. (2017). Engaging High School Girls in Native American Culturally Responsive STEAM Activities. *Journal of STEM Education: Innovations and Research, 18*(5), 15–25.

Kárpáti, A. (2019). Art education in Central and Eastern Europe. *In: Freedman, K. Ed.: International Encyclopedia of Art and Design Education, Vol. II: Curricular aspects of art & design education*. Wiley Blackwell Publishers, Oxford and New York. https://doi.org/10.1002/9781118978061.ead107

Kasbary, N., & Novák, G. M. (2024). Drama in STEAM education: Possible approaches and connections to drama-based activities in STEAM education. *Hungarian Educational Research Journal.* https://doi.org/10.1556/063.2024.00272

Katz-Buonincontro, J. (2018). Gathering STE(A)M: Policy, curricular, and programmatic developments in arts-based science, technology, engineering, and mathematics education. *Arts Education Policy Review, 119*(2), 73–76. https://doi.org/10.1080/10632913.2017.1407979

Kasza, P., & Slater, F. (2017). A survey of best practices and key learning objectives for successful secondary school STEM academy settings. *Contemporary Issues in Education Research, 10*(1), 53–66. https://doi.org/10.19030/cier.v10i1.9880

Keane, L., & Keane, M. (2016). STEAM by design. *Design and Technology Education, 21*(1), 61–82.

Kim, B. H., & Kim, J. (2016). Development and validation of evaluation indicators for teaching competency in STEAM education in Korea. *Eurasia Journal of Mathematics, Science & Technology Education, 12*(7), 1909–1924.

Kim, H. S., Kim, H., & Park, Y. H. (2015). Development of STEAM educational games focused on aesthetic and bodily expression in K-12 science class. *Communications in Computer and Information Science*, *529*, 265–270. https://doi.org/10.1007/978-3-319-21383-5_45

Kim, Y. E., Morton, B. G., Gregorio, J., Rosen, D. S., Edouard, K., & Vallett, R. (2019). Enabling creative collaboration for all levels of learning. *Proceedings of the National Academy of Sciences, 116*(6), 1878–1885. https://doi: 10.1073/pnas.1808678115

Kim, S., & Park, S. M. (2014). Determinants of job satisfaction and turnover intentions of public employees: evidence from US federal agencies. *International Review of Public Administration, 19* (1), 63–90. https://doi.org/10.1080/12294659.2014.887354.

Kirschner, P. A. (2015). Do we need teachers as designers of technology enhanced learning? *Instructional Science*, *43*(2), 309–322.

Knapp, N. F. (2018). Increasing interaction in a online flipped classroom through video conferencing. *TechTrends, 62*(6), 618–624. https://doi.org/10.1007/s11528-018-0336-z

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools*, *19*(3), 267–277. https://doi.org/10.1177/1365480216659733

Krajcik, J. S., Blumenfeld, P. C., Marx, R. W., & Soloway, E. (1994). A collaborative model for helping middle-grade science teachers learn project-based instruction. *Elementary School Journal*, *94*, 483–497.

Kreber, C. (2008). The modern research university and its disciplines: The interplay between contextual and context-transcendant influences on teaching. In C. Kreber (Ed.), *The University and its disciplines: Teaching and learning within and beyond disciplinary boundaries* Routledge.

Kritsis, K., Gkiokas, A., Lamerand, Q., Piéchaud, R., Acosta, C., Kaliakatsos-Papakostas, M., & Katsouros, V. (2018, January 11). *Design and interaction of 3D virtual music instruments for STEAM education using web technologies* [International Conference on Sound and Music Computing (SMC2018)].

Kumar, R. (2005). *Research Methodology: A Step-by-Step Guide for Beginners*. London: SAGE.

LaJevic, L. (2013). Arts integration: What is really happening in the elementary classroom? *Journal for Learning Through the Arts*, *9*(1), 1–28.

Land, M. H. (2013). Full STEAM ahead: The benefits of integrating the arts into STEM. *Procedia Comput. Sci. 20*, 547–552.

Lantz, H. B. (2009). Science, technology, engineering, and mathematics (STEM) education: What form? What function? *CurrTech Integrations.* Retrieved from http://www.currtechintegrations.com/pdf/STEMEducationArticle.pdf

Larmer, J., Mergendoller, J., & Boss, S. (2015). *Setting the Standard for Project-Based Learning*. Alexandria, VA: ASCD.

https://files.ascd.org/staticfiles/ascd/pdf/siteASCD/publications/books/Setting-the-Standard-for-PBL-sample-chapters.pdf

Leszczynski, E., Monahan, C., Munakata, M., & Vaidya, A. (2017). The Windwalker Project: An Open-Ended Approach. *Journal of College Science Teaching, 46*(6), 27-33.

Liao, C. (2016). From interdisciplinary to transdisciplinary: An arts-integrated approach to STEAM Education. *Art Education, 69*(6), 44–49. https://doi.org/10.1080/00043125.2016.1224873

Liao, J. C., Motter, L., & Patton, R. M. (2016). Tech-savvy girls: Learning 21st-century skills through STEAM digital artmaking. *Art Education, 69*(4), 29-35.

Li, K. C., & Wong, B. T. M. (2020). Trends of learning analytics in STE(A)M education: A review of case studies. *Interactive Technology and Smart Education, 17*(3), 323–335. https://doi.org/10.1108/ITSE-11-2019-0073

Lichtenberg, J., Woock, C., & Wright, M. (2008). Ready to innovate: Are educators and executives aligned on the creative readiness of the US workforce? New York: Conference Board.

Liliawati, W., Rusnayati, H., Purwanto, & Aristantia, G. (2018). Implementation of STEAM education to improve mastery concept. IOP Conf. Ser.: Mater. Sci. Eng. 288, 012148. doi: 10.1088/1757-899X/288/1/012148

Lincoln, Y. S., & Guba, E. G. (2013). *The Constructivist Credo.* Left Coast Press.

Long II, R., & Davis S. (2017). Using STEAM to increase engagement and literacy across disciplines. *The STEAM Journal, 3*(7), 1-13. https://scholarship.claremont.edu/cgi/viewcontent.cgi?article=1148&context=steam

Lu, C. C., & Ma, S. Y. (2019). Design STEAM course to train STEAM literacy of primary students: taking "Animal Mimicry Beast" as an example. *Journal of Research in Education Sciences, 64*(3), 85–118. https://doi.org/10.6209/JORIES.201909_64(3).0004.

Mace, N. (2018). *How educators can help close the STEM gender gap*. Concordia University-Portland. Retrieved February 5, 2024, from https://education.cuportland.edu /blog/classroom-resources/educators-steamgender-gap/

Madden, M. E., Baxter, M., Beauchamp, H., Bouchard, K., Habermas, D., & Huff, M. (2013). Rethinking STEM Education: An Interdisciplinary STEAM Curriculum. *Procedia Computer Science, 20*, 541–546.

Maeda, J. (2013). STEM Art = STEAM. *Steam, 1*(1), 1–3. https://doi:10.5642/steam.201301.34

Malinina, I. (2023). Interactive drama in initial teacher education: developing pre-service teachers' empathy. Research in Drama Education: *The Journal of Applied Theatre and Performance*. https://doi: 10.1080/13569783.2023.2274608

Margot, K. C., & Keller, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. *Journal of STEM Education, 6*(2). https://doi.org/10.1186/s40594-018-0151-2

Marshall, J. (2014). Transdisciplinary and art integration: Toward a new understanding of art-based learning across the curriculum. *Studies in Art Education, 55*(2), 104–127. https://doi.org/10.1080/00393541.2014.11518922

Marmon, M. (2019). Chapter 6 The Emergence of Science, Technology, Engineering, Art and Mathematics (STEAM) in the Field of Higher Education. In, *STEAM Education: Theory and Practice* (pp.101-115). Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-04003-1

Mastrorilli, T. M., Harnett, S., & Zhu , J. (2014). Arts Achieve, Impacting Student Success in the Arts: Preliminary Findings After One Year of Implementation. *Journal for Learning Through the Arts, 10*(1), 1-24. https://doi.org/10.21977/D910119266

May, G. S. (2015). STEM, not STEAM. Retrieved from https://www.insidehighered.com/views/2015/03/30/essay-criticizes-idea-adding-arts-push-stem-education

McGregor, D. (2012). Dramatising Science Learning: Findings from a Pilot Study to Re invigorate Elementary Science Pedagogy for five-to seven-year-olds. *International Journal of Science Education, 34*(8), 1145–1165. https://doi.org/10.1080/09500693.2012.660751

McGregor, D. (2014). Chronicling Innovative Learning in Primary Classrooms: Conceptualizing a Theatrical Pedagogy to Successfully Engage Young Children Learning Science. *Pedagogies: An International Journal, 9*(3), 1-17.

McKlin, T., Magerko, B., Lee, T., Wanzer, D., Edwards, D., & Freeman, J. (2018). *Authenticity and Personal Creativity: How EarSketch Affects Student Persistence.* [Proc. of the 49th ACM Technical Symposium on Computer Science Education, ACM, New York, NY, USA] 987–992.

Merriam, S. B. (2002). *Qualitative Research in Practice: Examples for Discussion and Analysis*. San Francisco, CA: Jossey-Bass

Merriam, S. B. (2009). *Qualitative Research: A Guide to Design and Implementation*. San Francisco, CA: John Wiley & Sons.

Mertens, D. M. (2010). *Research and Evaluation in Education and Psychology: Integrating diversity with quantitative, qualitative, and mixed methods* (3rd ed.) Thousand Oaks, CA: Sage

Meyer, D. K., & Turner, J. C. (2006). Re-conceptualizing Emotion and Motivation to Learn in Classroom Contexts. *Educational Psychology Review, 18*, 377–390. https://doi/10.1007/s10648-006-9032-1

Michaud, M. R. (2014). K-12 Students see STEAM everyday. *The STEAM Journal*, 1(2). https://doi:10.5642/steam.20140102.33

Miles, M.B., Huberman, A.M., & Saldana, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook*. Sage, London.

Miller , B. T., Camarda, A., Mercier, M., Burkhardt, J. M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon , F., El Hayek, S., Landais, M. A., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T.

(2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. *Journal of Intelligence, 11*(54), 1-32. https://doi.org/https://www.mdpi.com/journal/jintelligence

Milne, A. J., & Calilhanna, A. (2019, June 18-21). *Teaching Music with Mathematics: A Pilot Study* [Mathematics And Computation In Music: 7th International Conference, Mcm]. Proceedings. https://doi.org/10.1007/978-3-030-21392-3_34

Milner-Bolotin, M., & Milner, V. (2017). Family Mathematics and Science Day at UBC Faculty of Education. *Physics in Canada, 73*(3), 130-132.

Mishra, P., & Henriksen, D. (2013). A new approach to defining and measuring creativity: Rethinking technology & creativity in the 21st century. *TechTrends, 57*(5), 10.

Moon, K. (2019). *A case study of the perceptions of education stakeholders of STEAM integration in a K–8 setting* [Master's Thesis, Concordia University]. Digital Commons @ CSP. https://digitalcommons.csp.edu/cup_commons_grad_edd/449

Morton, B. G., Gregorio, M. J., Rosen, D. S., Vallett, R., & Kim, Y. (2017). STEAM education through Music Technology (evaluation). *American Society for Engineering Education.*

Moyer, L., & Miller, T. (2017). Cultivating community resources: Formal and nonformal educators partner to change the world…one step at a time. *Children's Technology and Engineering, 22*(2), 16–19.

NAEA Research Commission (2014) NAEA Research Agenda. National Art Education Association. https://wwwarteducators.org/research/commission/findings-resources

Nadelson, L., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfiester, J. (2013). Teacher STEM perception and preparation: Inquiry-based STEM professional development for elementary teachers. *The Journal of Educational Research, 106* (2), 157–168. https://eric.ed.gov/?id=EJ1011969

National Art Education Association [NAEA] (2016). Using art education to build a stronger workforce. https://arteducators-prod.s3.amazonaws.com/documents/535/ff8bfae5-6b4f-4352-b900-4fc1182ad2b1.pdf?1455134278.

National Coalition for Core Art Standards [NCCAS] (2013). The national core arts standards: A conceptual framework for arts learning. https://www.nationalartsstandards.org/sites/default/files/NCCAS%20%20Conceptual%20Framework_0.pdf

National Core Arts Standards Media Arts Resource. (n.d.) Retrieved from http://www.nationalartsstandards.org/sites/default/files/MA-JC5-15R.pdf

National Research Council. 2011. *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13158.

National Post. (2018, Feb 12). STEAM Academy is Revolutionizing How Students Learn. Retrieved from https://nationalpost.com/sponsored/life-sponsored/steam-academy-is-revolutionizing-how-students-learn

Nguyen, V., Nguyen, T., Lin, P., Lin, J., & Chang, C. (2020). Measuring teachers' perceptions to sustain STEM education development. *Sustainability, 12*(4). https://www.mdpi.com/2071-1050/12/4/1531

Norton, P., & Hathaway, D. (2015). In search of a teacher education curriculum: Appropriating a design lens to solve problems of practice. *Educational Technology, 55*(6), 3–14.

Novák, G. M. (2019). Applied drama and forum theatre in the classroom: An arts-based research in social integration. *Hungarian Educational Research Journal* 2019, *9*(3), 569-573. https://doi.org/10.1556/063.9.2019.3.47

Nweke, E.N., and Nwoba, C.C (2019). Method of Data Collection in Okoli, A.M., and Ajene O. G. (2019). *Research methodology in Social Science analysis*. Nigeria: Willyrose and Appleseed Publishing Company.

OECD. (2019). OECD Future of Education and Skills 2030: OECD Learning Compass 2030. Retrieved from The Organization for Economic Co-operation and Development: http://www.oecd.org/education/2030-project/teaching-andlearning/learning/skills/

OECD Teaching and Learning International Survey TALIS. (2009). https://download.ei-ie.org/Docs/WebDepot/OECD%20TALIS%20Report_EI%20Analysis.pdf

Oh, J., Lee, J., & Kim, J. (2013). Development and application of STEAM based education program using scratch: Focus on 6th graders' science in elementary school. *Multimedia and Ubiquitous Engineering*. 493–501.

O'Leary, R. & Thompson, E. (2019). STEM to STEAM: Effect of visual art integration on long-term retention of science content. *Journal of Leadership and Instruction, 18*(1). 32-35.

Oner, A. T., Nite, S. B., Capraro, R. M., & Capraro, M. M. (2016). From STEM to STEAM: Students' Beliefs About the Use of Their Creativity. *The STEAM Journal, 2*(2), https://doi: 10.5642/steam.20160202.06. Available at: https://scholarship.claremont.edu/steam/vol2/iss2/6

Ozkan, G., & Topsakal, U. (2017). Examining students' opinions about STEAM activities. *Journal of Education and Training Studies, 5*(9), https://files.eric.ed.gov/fulltext/EJ1151682.pdf

Pallasmaa, J. (2009). *The Thinking Hand*. United Kingdom: John Wiley & Sons Ltd.

Park, N. (2014). The development of STEAM career education program using virtual reality technology. *Life Science Journal, 11*(7), 1097–8135 www.lifesciencesite.com.97

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Patton, R. M., & Knochel, A. D. (2017). Meaningful Makers: Stuff, Sharing, and Connection in STEAM Curriculum. *Art Education, 70*(1), 36-43.

Peppler, K., & Wohlwend, K. (2018). Theorizing the nexus of STEAM practice. *Arts Education Policy Review, 119*(2), 88–99.

Perignat, E., & Katz-Buonincontro, J. (2019). STEAM in practice and research: An integrative literature review. *Thinking Skills and Creativity, 31*. 31–43. https://doi.org/10.1016/j.tsc.2018.10.002

Petticrew, M., & Roberts, H. (2006). *Systematic Reviews in the Social Sciences: A Practical Guide.* Blackwell Publishing. https://doi.org/10.1002/9780470754887

Piaget, J. (1973). *Psychology and Epistemology: Towards a Theory of Knowledge.* Record: Rio de Janeiro.

Plattner, H., Meinel, C., & Leifer, L. (2015). *Design Thinking Research Building Innovators*. Springer. https://doi.org/10.1007/978-3-319-06823-7

Pomeroy, S. R. (2012). From STEM to STEAM: Science and Art go Hand in Hand. Scientific American.https://blogs.scientificamerican.com/guestblog/fromstemtosteamscienceandtheartsgohandinhand/

Purakom, A., & Soykeree, T. (n.d.). STEM Education: Innovation Education for Young Generation. *ASEAN*. 9–12.

P21. (2002). The Partnership for 21st Century Learning. Retrieved from http://www.p21.org/

Quigley, C., & Herro, D. (2016). Finding the joy in the unknown: Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal of Science Education and Technology, 25*(3). 410-426.

Quigley, C., & Herro, D. (2017). Exploring teachers' perceptions of STEAM teaching through professional development: implications for teacher educators. *Professional Development in Education, 43*(3). 416-438.

Quigley, C. F., Herro, D., & Jamil, F. M. (2017). Developing a conceptual model of STEAM teaching practices. *School Science and Mathematics, 117*(1–2), 1–12. https://doi.org/10.1111/ssm.12201

Rabalais, M. (2014). *STEAM: A national study of the integration of the arts into STEM instruction and its impact on student achievement* [Doctoral Dissertation, University of Louisiana, Lafayette]. https://www.proquest.com/openview/d4dadbab54198740e20fd2bf013ed5d4/1?pq-origsite=gscholar&cbl=18750&diss=y

Radziwill, N. M., Benton, M. C., & Moellers, C. (2015). From STEM to STEAM: Reframing What it Means to Learn. *The STEAM Journal, 2*(1), 3. https://doi:10.5642/steam.20150201.3

Remake Learning. (2016). https://remakelearning.org/about/

Réti, M., Horváth, D., Czippán, K., Varga, A. (2015). The Challenge of Mainstreaming ESD in Hungary. In: Jucker, R., Mathar, R. (eds) Schooling for Sustainable Development in Europe.

Schooling for Sustainable Development, vol 6. Springer, Cham. https://doi.org/10.1007/978-3-319-09549-3_12

Richard, B., & Treichel, C. J. (2013). Increasing secondary teachers' capacity to integrate the arts. The Clearing House: A Journal of Educational Strategies, *Issues and Ideas, 86*(6), 224–228. https://doi:10.1080/00098655.2013.826488

Riley, S. (2013). Pivot point: At the crossroads of STEM, STEAM, and arts integration. Retrieved from http://www.edutopia.org/blog/ pivot-point-stem-steam-arts-integration-susan-riley

Rinvolucri, M. (1994). Key concepts in elt: feedback. *ELT J. 48*, 287–8. https://doi:10.1093/elt/48.3.287

Ritchhart, R. (2015). *Creating Cultures of Thinking: The 8 Forces We Must Master to Truly Transform Our Schools*. San Francisco: Jossey-Bass.

Robson, C., & McCartan, K. (2016). *Real World Research* (4th ed.). Wiley.

Roehrig, G.H., Dare, E.A., & Ellis, J.A. (2021). Beyond the basics: a detailed conceptual framework of integrated STEM. *Discip Interdscip Sci Educ Res, 3*(11) https://doi.org/10.1186/s43031-021-00041-y

Rolling, J. H. (2016). Reinventing the STEAM engine for art and design education. *Art Education. 69*(4), 4–7.

Sabol, F. R. (2010). No child left behind: A study of its impact on art education. *National Art Education Association.* https://www.arteducators.org/research/articles/107-no-child-leftbehind

Sakon, T., & Petsangsri, S. (2021). STEAM Education for Enhancing Creativity in Packaging Design. *Archives of Design Research, 34*(1), 21-31.

Saldana, J. (2013). *The Coding Manual for Qualitative Researchers* (2nd ed.). London: Sage.

Sanders, M. (2009). STEM, STEM Education, STEMmania. *The Technology Teacher*, 20-26.

Sanghera, B. (2001). *Qualitative Research Methods: Participant Observation*. http://uk.geocities.com/balihar_sanghera/qrmparticpantobservation.html.

Sarantakos, S. (1998). *Social Research* (2nd ed.), MacMillan Education Australia, South Melbourne.

Sawyer, R. K. (2011). *Structure and improvisation in creative teaching*. Cambridge, UK Cambridge University Press.

Schleicher, A. (2018). Reimagining the teaching profession. *Teacher Magazine*. Retrieved from https://www.teachermagazine.com.au/columnists/andreasschleicher/reimagining-theteachingprofession?utm_source=CM&utm_medium=bulletin&utm_conten%E2%80%A6

Scientix. www.scientix.eu

Segarra, A. V., Naralizio, B., Falkenberg, V. C., Pulford, S., & Holmes, M. R. (2---). STEAM. Using the Arts to Train Well-Rounded and Creative Scientists. *Journal of Microbiology and Biology Education, 19*(1). 2-3. https://doi.org/10.1128/jmbe.v19i1.1360

Segura, A. W. (2017, January 10). *The use of STEAM in higher education for high school teachers* [The 21st World Multi-Conference on Systemics, Cybernetics and Informatics]. Faculta de Educación Universidad Galileo. 308-312.

Seferoglu, S. S., & Akbıyık, C. (2006). Teaching critical thinking. *Hacettepe University Journal of Education, 30*, 193-200.

Shank, G. D. (2006). *Qualitative Research: A Personal Skills Approach*. Pearson Merrill Prentice Hall.

Sharapan, H. (2012). From STEM to STEAM: How early childhood educators can apply Fred Rogers' approach. *YC Young Children, 67*(1), 36.

Shen, S., Wang, S., Qi, Y., Wang, Y., & Yan, X. (2021). Teacher Suggestion Feedback Facilitates Creativity of Students in STEAM Education. *Front. Psychol. 12* https://doi: 10.3389/fpsyg.2021.723171

Shernoff, D.J., Sinha, S., & Bressler, D.M. (2017). Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education. *IJ STEM Ed, 4*(13). https://doi.org/10.1186/s40594-017-0068-1

Shin, Y., & Han, S. (2010). A study of the elementary school teacher's perception in steam (science, technology, engineering, arts, mathematics) education. *Journal of Korean Elementary Science Education, 30*(4), 514-523. http://koreascience.or.kr/article/JAKO201113663906083.page

Silverstein, L. B., & Layne, S. (2010). Defining arts integration. *Washington, D. C.: The John F. Kennedy for the Performing Arts.* Retrieved from http://www.kennedycenter.org/education/partners/defining_arts_integration.pdf

Sousa, D., & T. Pilecki. (2013). *From STEM to STEAM: Using brain-compatible strategies to integrate the arts.* London: Sage Publications.

Sparks, D. (2002). Designing powerful professional development for teachers and principals. *National Staff Development Council*. http://beersheva.pisga.edu.gov.il/exlteacher/DocLib19/Desining%20powerful%20professional%20development.pdf

Spector, J. M. (2015). Education, training, competencies, curricula and technology. In *Emerging Technologies for STEAM Education*. 3-14. Springer International Publishing.

Spradley, J. P. (1980). *Participant Observation*. New York: Holt, Rinehart, and Winston.

Spyropoulou, C., Wallace, M., Vassilakis, C., & Poulopoulos, V. (2020). Examining the use of STEAM Education in Preschool Education. *European Journal of Engineering Research and Science*, (Special Issue: CIE). https://doi.org/http://dx.doi.org/10.24018/ejers.2020.0.CIE.2309

Stansbury, M. (2011). Panel: STEM education crisis stems from unsupported teachers. *eSchool News.* Retrieved from http://www.eschoolnews.com/2011/09/14/panelstem-education-crisis-stems-from-unsupported-teachers/

Stake, R. E. (2010). *The Art of Case Study Research*. Thousand Oaks, CA: Sage.

Stein, M.I. (1953). Creativity and Culture. *Journal of Psychology, 36,* 311-322. http://dx.doi.org/10.1080/00223980.1953.9712897

Stein, M., & Muzzin, M. (2018). Learning from failure. *Science and Children, 55*(8), 62– 65.

Stubbs, E. A., & Meyers, B. E. (2015). Multiple case study of STEM in school-based agricultural education. *Journal of Agricultural Education, 56*(2), 188–203. https://doi:10.5032/jae.2015.02188

Szabo, M; Varga, A; Pallag, A., & Filo, M. (2018). The Hungarian 'STEAM ENGINE'- Schools and Social Partners for STEAM Education. 125-138.

Tait, A., & Faulkner, D. (2016). *Edupreneur: Unleashing Teacher-Led Innovation in Schools*. Melbourne: Wiley.

Taylor, P. (2016). *Why is a STEAM curriculum perspective crucial to the 21st century?* [ACER Research Conferences]. https://research.acer.edu.au/research_conference/RC2016/9august/6/

Timotheou, S., & Ioannou, A. (2019). On Making, Tinkering, Coding and Play for Learning: A Review of Current Research. *Human-Computer Interaction – INTERACT 2019*.

Tippett, C. D. & Milford, T. M. (2017). Findings from a Pre-kindergarten Classroom: Making the Case for STEM in Early Childhood Education. *International Journal of Science and Mathematics Education, 15*, 67–86. https://doi.org/https://doi.org/10.1007/s10763-017-9812-8.

Tesconi, S., & de Aymerich, B. (2020). *Ciencia en todo y para todos. In D. Couso, M. R. Jimenez-Liso, C. Refojo, & J. A. Sacristán (Eds.), Enseñando Ciencia con Ciencia*. FECYT & Fundacion Lilly. Penguin Random House. 88–99

The Institute for Arts Integration and STEAM (2021) https://artsintegration.com/guide-to-arts-integration/

Thomas, K., & Chan, J. (2013). Negotiating the paradox of creative autonomy in the making of artists. *Studies in Art Education, 54*(3), 260-272. Retrieved from http://www.arteducators.org/research/studies

Thurman, B. (2009). Teaching of critical thinking skills in the English content area in South Dakota public high schools and colleges. *Education Resources Information Center.* ERIC ED513229.

Togou, M. A., Lorenzo, C., Cornetta, G., & Muntean, G. M. (2020).Assessing the effectiveness of using fab lab-based learning in schools on K-12 Students' attitude toward STEAM. *IEEE Transactions on Education, 63*(1), 56–62. https://doi.org/10.1109/TE.2019.2957711

UDIR. (2019). Læreplan i engelsk. Retrieved from https://www.udir.no/kl06/ENG1-03/Hele/Formaal

UNESCO. (2023). Futureproofing students' skills through STEAM and Coding in Palestine. https://www.unesco.org/en/articles/futureproofing-students-skills-through-steam-and-coding-palestine?hub=701

Upitis, R. (2011). Engaging students through the arts. What works? *Research Into Practice,* (33), 1–4.

Vann, C. B. (2013). Pioneering a new path for STEM education. *Industrial Engineer: IE, 45*(5), 30.

Vasquez, J. A., Comer, M., & Sneider, C. (2013). *STEM lesson essentials: Integrating science, technology, engineering and mathematics.* Portsmouth, NH: Heinemann Publications.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.). Cambridge, MA: Harvard University Press.

Wagner, T. (2012). *Creating Innovators - The Making of Young People Who Will Change the World*. New York: Scribner

Wahyuningsih, S., Nurjanah, N. E., Rasmani, U. E., E, Hafidah, R., Pudyaningtyas, A. R., & Syamsuddin, M. M. (2018). STEAM Learning in Early Childhood Education: A Literature Review. *International Journal of Pedagogy and Teacher Education*, *4*(1), 33-44. https://doi.org/10.20961/ijpte.v4i1.39855

Wang, H. (2012). A new era of science education: Science teachers' perceptions and classroom practices of science, technology, engineering, and mathematics (STEM) integration.

Wang, H. H., Moore, T. J., Roehrig, G. H., & Park, M. S. (2011). STEM integration: Teacher perceptions and practice. *Journal of Pre-College Engineering Education Research (J-PEER), 1*(2), 1–13. https://docs.lib.purdue.edu/jpeer/vol1/iss2/2/

Wang, S. T., Liu, L. M., & Wang, S. M. (2018, November 1). *The Design and Evaluate of Virtual Reality Immersive Learning - The Case of Serious Game "Calcium Looping for Carbon Capture."* [International Conference on System Science and Engineering, ICSSE 2018.]. https://doi.org/10.1109/ICSSE.2018.8520002

Watson, A. D., & Watson, G. H. (2013). Transitioning STEM to STEAM: Reformation of Engineering Education. *The Journal for Equality and Participation*, 1-4. https://www.academia.edu/8766909/Transitioning_STEM_to_STEAM_Reformation_of_Engineering_Education

Watson, A. D. (2015). Design Thinking for life. *Art Education, 68*(3), 12-18. https://doi.org/10.1080/00043125.2015.11519317

Watson, A. D. (2016). Revving Up the STEAM Engine. *Art Education*, *69*(4), 8–9. https://doi.org/10.1080/00043125.2016.1178032Watson, A. D., & Watson, G. H. (2013). Building both sides of the brain: Innovating by blending form and function. *The Journal for Quality and Participation, 36*(3), 9.

Wellington, A., Easton, G., Davis, J. P., & Yeh, A. (2020). Beat and Rhythm: Teaching science via integrated STEAM and digital technologies. *Teaching Science, 66*(2), 20–25.

Winne, P. H., & Butler, D. L. (1994). *Student cognition in learning from teaching*. In International Encyclopedia of Education (2nd ed), eds T. Husen, T. Postlewaite (Oxford, UK: Pergamon), 5738–45.

Winthrop, R., McGivney, E., Williams, T. P., & Shankar, P. (2017). *Innovation and technology to accelerate progress in education.* Brookings. https://www.brookings.edu/research/innovation-and-technology-to-accelerate-progressin-education/

White, H. P. (2010). STEAM not STEM whitepaper: An agreement on what drives the US economy in the future. http://steam-notstem.com

Wynn, T., & Harris, J. (2012). Toward a STEM + arts curriculum: Creating the teacher team. *Art Education, 65*(5), 42–47. Retrieved from http://www.artsintegrationams.com/references.html

Yakman, G. (2008, February). *STEAM education: An overview of creating a model of integrative education* [Pupils' attitudes towards technology(PATT-19) Conference]. Research on Technology, Innovation, Design & Engineering Teaching. https://www.researchgate.net/publication/327351326_STEAM_Education_an_overview_of_creating_a_model_of_integrative_education

Yakman, G. (2012). Recognizing the A in STEM education. *Middle Ground, 16*(1), 15–16

Yakman, G., & Lee, H. (2012). Exploring the exemplary STEAM education in the U.S. as a practical education framework for Korea. *Journal of the Korean Association for Research in Science Education, 32*(6), 1072-1086.

Yin, R. K. (2009). *Case Study Research: Design and Methods*. Thousand Oaks, CA: Sage.

Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th ed.). London, England: Sage Publication.

Zamorano, E. T., García-Cartagena, Y., & Reyes-González, D. (2018). Educación para el sujeto del siglo XXI: Principales características del enfoque STEAM desde la mirada educacional. Contextos Estud. Humanid. Cienc. *Soc, 41*, 1–21.

Zaratin, J. (2020). *Implementing S.T.E.A.M. – one school's journey toward implementation.* [Doctoral Dissertation, St. John's University]. St. John's Scholar. https://scholar.stjohns.edu/cgi/viewcontent.cgi?article=1071&context=theses_dissertations

Zimmerman, A. (2016). Developing confidence in STEAM: Exploring the challenges that novice elementary teachers face. *Steam*, *2*(2), 1–9. https://doi:10.5642/steam.20160202.15

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25*(1), 82–91. https://doi.org/10.1006/ceps.1999.1016

Appendix 1

Letter of Information

Project Title: The Importance of Integrating Art-Based Methods in STEM Education

Document Title: Letter of Information

This letter is to address and explain what the research is about and it will give a brief description of the researcher in charge of this project.

My name is Nicole Kasbary and I am currently a PhD student at Eotvos Lorand University in Budapest, Hungary. I am enrolled in the Faculty of Education, specializing in the Adult Learning Program. This is a 4 year program and have spent the majority of my studies in Budapest itself. I am conducting interviews, questionnaires, and observations to collect data for my research. The topic of my research is the importance of integrating arts-based methods in STEM education. STEM is an acronym for science, technology, engineering, and math and the research is trying to add arts-based methods to become STEAM education. The research collects literature that defends this concept and explains how vital and beneficial arts-based methods are for individuals. Arts promotes many aspects which include, collaboration, creativity, innovations, individuality, problem and critical thinking skills, and much more. The research is trying to promote the arts and their uses to be associated in classrooms, but more importantly in curriculums. Data will be collected, transcribed, analyzed, and a comparison from three different countries- Hungary and Palestine. A qualitative method approach is used from a collection of literature, interviews, and observation. The target groups include- high school administrators, high school teachers, and lastly high school students from Hungary and Palestine. I will conduct interviews with high school administrators, teachers, and students to get a narrative perspective about STEAM education and

the importance of arts. I will enter classrooms and create activities for STEAM and then observe students and teachers on their take on STEAM. Subsequently, a questionnaire will be handed out to the teachers and students where they will personally express their opinions on STEAM and the arts are beneficial and can aid in their future careers. The main goal of the research is to promote the importance of arts-based methods in classrooms and STEM subjects by collecting the necessary data. To better understand and obtain different perspectives the interview will consist of a series of questions based on the importance of arts, STEAM education, and its implementation in classrooms. Thank you for giving me the chance to explain my research and its goals. The interview will take between 30-60 minutes. Every interviewee will be handed a consent form to fill out and if agreed their responses and personal information will be transcribed only into the research and no place else. The interview will either be audio or video recorded depending on the interviewee's wishes. There will be questions and the answers will be transcribed into the research. Thank you for your participation and engagement in my research to reach positive results.

Appendix 2

Consent Form for Students under 18- Audio or Video Recording

Project Title: The Importance of Implementing and Integrating Arts-based Methods in STEM Education

Document Title: Consent Form

Principal and Contact of School:

I have read the Letter of Information about the project entitled above and had the project explained to me and agree to participate in this project with my parent's permission.

I consent for my daughter or son to participate in the interview and be part of this research.

☐ Yes ☐ No

I agree to be either audio or video recorded. Check the box that applies-

☐ Interview Audio Recorded ☐ Interview Video Recorded

I consent to the interviewer to use my quotes and transcribe them into her research.

☐ Yes ☐ No

Name of Teacher :

Name of Parent or Guardian:

Signature of Parent or Guardian:

Signature of Student: **Date:**

Appendix 3

Consent Form for Students above 18- Audio or Video Recording

Project Title: The Importance of Implementing and Integrating Arts-based Methods in STEM Education

Document Title: Consent Form

Principal and Contact of School:

I have read the Letter of Information about the project entitled above and had the project explained to me and agree to participate in this project.

☐ Yes ☐ No

I agree to be either audio or video recorded. Check the box that applies-

☐ Interview Audio Recorded ☐ Interview Video Recorded

I consent to the interviewer to use my quotes and transcribe them into her research.

☐ Yes ☐ No

Name of Teacher:

Name of Student:

Signature of Student:

Date:

Appendix 4

Consent Form for Administrators and Teachers- Audio or Video Recording

Project Title: The Importance of Implementing and Integrating Arts-based Methods in STEM Education

Document Title: Consent Form

Principal and Contact of School:

I have read the Letter of Information about the project entitled above and had the project explained to me and agree to participate in this project.

☐ Yes ☐ No

I agree to be either audio or video recorded. Check the box that applies-

☐ Interview Audio Recorded ☐ Interview Video Recorded

I consent to the interviewer to use my quotes and transcribe them into her research.

☐ Yes ☐ No

Name of Administrator or Teacher:

Signature of Administrator or Teacher:

Date:

Appendix 5

Informed Consent and Description of Research In-Person Participation Students below 18

Dear Parent/Guardian of Student,

You are invited to participate in a questionnaire by Novák Géza Máté Ph.D. (research leader, Eötvös Loránd University) and Nicole Kasbary (PhD student, Eötvös Loránd University) who are coordinating the research. This study aims to collect the teachers' and students' perceptions of STEAM education and the importance of arts. Participation is utterly voluntary. This consent form will be sent to the student's parent or guardian if either agrees to take part in this study. If agreed the student will be asked to do a STEAM activity, followed by a questionnaire about the activity and what are the benefits of arts-based methods. In the framework of this research, we hope to extend the existing knowledge of the students' perceptions of implementing STEAM activities in their classrooms. The questionnaire will take only 10-15 minutes to complete for there are only 10 statements to either agree or disagree with. Filling out the questionnaire is completely harmless and does not have any detrimental after-effects. Also, no medical or laboratory report will be prepared about the results of the study. It is possible to cease or stop participating in the questionnaire at any given moment and no need to specify why. Monetary compensation will not be due for participation. The results of this study will later be used in publications and could be presented at scientific conferences.

All the data and personal information that will be obtained during the interview will be stored as coded information on a secure external hard drive with a password code. The individual codes are provided by the assistant in charge, and these are accessible and known only to her. The document with the rules regulating personal data processing (General Data Protection Regulation, GDPR) is attached with its enclosures. If you have questions about this project or have a research-related problem, you may contact the researchers: Nicole Kasbary at nkasbary@student.elte.hu or Dr. Novák Géza Máté PhD at novak.geza@barczi.elte.hu. Please sign the agreement below you agree with the conditions outlined above and endorse participation in the study. We thank you for your collaboration.

I (the undersigned) declare that I- the parent or guardian was given thorough information regarding the circumstances of my daughter/son's participation in the present research. I agree with the conditions and allow my daughter/son to complete the questionnaire. I reserve the right to terminate participation at any time in which case the data belonging to my person should be erased. I am not (and have not been) treated for any kind of neurological or mental disease.

…….

date signature

By clicking **"I agree"** below you are showing that you are below 18 years old, have read, and understood this consent form, and agree to participate in this research study.

☐ I agree ☐ I do not agree

Appendix 6

Informed Consent and Description of Research In Person Participation above 18
Dear **Student,**

You are invited to participate in a questionnaire by Novák Géza Máté PhD (research leader, Eötvös Loránd University) and Nicole Kasbary (PhD student, Eötvös Loránd University) who are coordinating the research. The aim of this study is to collect the teachers' and students' perception of integrating the arts into STEM education and the importance of arts.

Participation is utterly voluntary. If you agree to take part in this study, you will be asked to complete a questionnaire about STEAM education and what are the benefits for arts-based methods. If agreed the student will be asked to do a STEAM activity, followed by a questionnaire and will take only 10-15 minutes to complete for there are only 10 statements to either agree or disagree. Filling out the questionnaire is completely harmless and does not have any detrimental after-effects. Also, no medical or laboratory report will be prepared about the results of the study. It is possible to cease or stop participating in the questionnaire at any given moment and no need to specify why. Monetary compensation will not be due for participation. The results of this study will later be used in publications and could be presented at scientific conferences.

All the data and personal information that will be obtained during the interview will be stored as coded information on a secure external hard-drive with a password code. The individual codes are provided by the assistant in charge, and these are accessible and known only to her. The document with the rules regulating personal data processing (General Data Protection Regulation, GDPR) is attached with its enclosures.

If you have questions about this project or have a research-related problem, you may contact the researchers: Nicole Kasbary at nkasbary@student.elte.hu or Dr. Novák Géza Máté PhD at novak.geza@barczi.elte.hu. Please sign the agreement below you agree with the conditions outlined above and endorse participation in the study. We thank you for your collaboration.

I (undersigned) declare that I was given thorough information regarding the circumstances of my participation in the present research. I agree with the conditions and to participate in the study. I reserve the right to terminate my participation at any time in which case the data belonging to my person should be erased. I am not (and have not been) treated for any kind of neurological or mental disease .

…….
date signature

By clicking **"I agree"** below you are showing that you are above least 18 years old, have read, understood this consent form, and agree to participate in this research study.

☐ I agree ☐ I do not agree

Appendix 7

Classroom Activities for STEAM Observation

Type of teaching. Check that applies to the activity:

☐ Lecture ☐ Seatwork

☐ Class discussion ☐ Collaborative learning

☐ Small group discussions

☐ Project-based learning

What was the task/activity?

Explain what the students were doing throughout the activity.

Explain students' expressions and body language during the activity.

Student Engagement:

☐ Low ☐ Medium ☐ High

Was arts integrated into the activity?

☐ Yes ☐ A Little ☐ No

What other methods were applied during the activity?

☐ Collaboration ☐ Engagement

☐ Innovation ☐ Effort

☐ Self-learning ☐ Other

☐ Critical thinking ☐ Problem-Solving

Appendix 8

These are the questions that were asked during the interviews, other questions were asked during the interview from the answers the participants gave. These questions were cohesive for all groups starting with the secondary principals:-

1. How can curriculums be developed?
2. What are new techniques and methods teachers should implement in their classrooms?
3. How can STEAM education benefit the students?
4. How can teachers learn to teach STEAM education in their classrooms?
5. Can STEAM education help students in finding a good job?
6. What are the regulations for developing or changing the curriculum?
7. Who seems to be the best fit in developing curriculums?

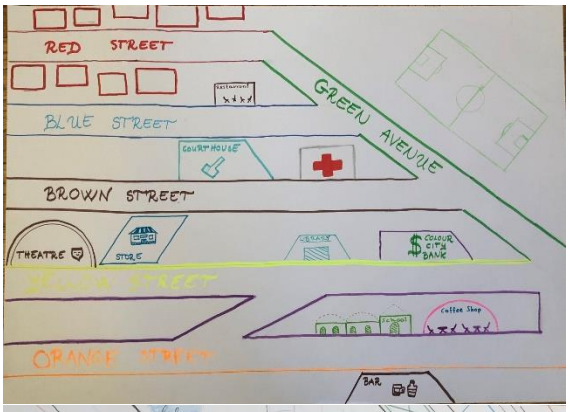
Interview questions for the secondary teachers:-

1. Why is STEAM education an important aspect of education?
2. Why is the art an important asset to STEM education?
3. Can students learn science, technology, engineering, and math without the arts?
4. How can schools or teachers integrate the arts into curriculums?
5. What are the main problems schools are facing with not developing the curriculums?
6. What are some changes teachers can make to develop curriculums and use STEAM education?
7. Is the government in charge of developing the curriculums or is it the school's responsibility?
8. What is project-based learning in your opinion and idea?
9. Can project-based learning benefit the students and give them a better and more advanced experience in their classroom?
10. What are some connections between project-based learning and STEAM education?
11. Do you know other high school teachers in other schools who know or use STEAM education in their teaching?
12. After understanding what STEAM education is, have you ever used it without knowing what it is?
13. What can you add to the idea of STEAM education?

Interview questions for the secondary students:-

1. What kind of activities do you know about STEAM education?
2. After doing some activities with STEAM education do you think you learned more?
3. Do you prefer teachers implementing STEAM activities in classrooms or not? Why?
4. As a student, what is your role in the classroom and lessons?
5. Who do you think has the power to develop curriculums and implement new teaching methods in classrooms?
6. How can STEAM education benefit your learning for the future?
7. Can STEAM education help you find better jobs in the future?
8. Is STEAM education efficient for creating new teaching techniques and methods?
9. Is STEAM education a new and modern way of teaching?
10. Have you ever been involved in STEAM or STEM activities outside of school? If yes, what was it?

Appendix 9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GREEN AVENUE
BLUE STREET
BROWN STREET
THEATRE
BAR


University
Park
Amphitheater
PUB
MARKET
NURSERY
PETROL STATION
St Stephen Cemetery

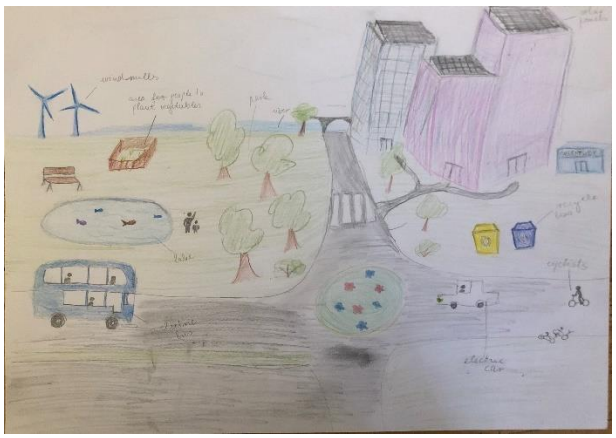

Restaurant
park
HOUSES
MALL
THEATRE
hospital
store
cinema

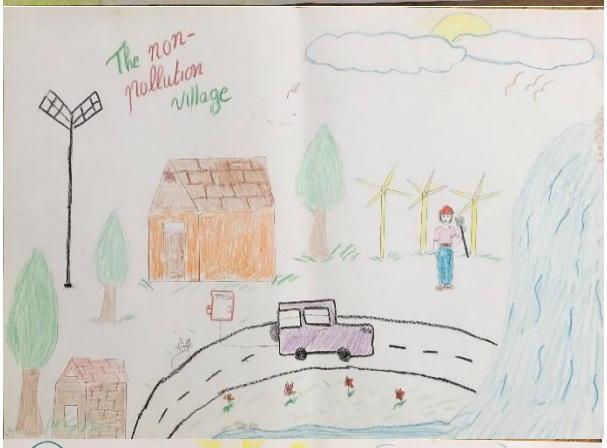

KFC
HAB CITY
HAB Mall
Park


Bank
Restaurant
Store
Library
Mall


SCHOOL
SPOTTY CAMP MOV


PARK
LAKE
ICE CREAM SHOP
MALL
Nela's home
RESTAURANT
BANK
STARBUCKS
Tesco

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