




DESIGNING A NEED-BASED INTEGRATED STEAM FRAMEWORK FOR PRIMARY SCHOOLS IN BAHRAIN

 Masooma Ali Al-Mutawah¹⁺
Yazan M. Alghazo²
Enaz Yousef
Mahmoud³
Nisha Preji⁴
Ruby Thomas⁵

^{1,2,3,4,5} Bahrain Teachers College, University of Bahrain, Bahrain.

¹Email: malmutawah@uob.edu.bh Tel: +97317437152

²Email: yalghazo@uob.edu.bh Tel: +97317437427

³Email: eyousef@uob.edu.bh Tel: +97317438710

⁴Email: npreji@uob.edu.bh Tel: +97317438978

⁵Email: rthomas@uob.edu.bh Tel: +97317437527



(+ Corresponding author)

ABSTRACT

Article History

Received: 2 April 2021

Revised: 29 June 2021

Accepted: 4 August 2021

Published: 26 August 2021

Keywords

Bahrain
Mathematics education
Primary education
STEAM activities
STEM curriculum
STEM education.

The significant global interest in 21st century skills and their incorporation into school curricula inspired the researchers of the current study to develop a new educational approach of designing curricula that incorporates science, mathematics, technology, arts and engineering (STEAM). In this study, the researchers reviewed several relevant frameworks of curriculum integration in elementary education. Based on previously suggested models, a new model was built up for curriculum development and a STEAM-based activity was presented specifically designed in accordance with the recent theoretical models and practices in STEM education, with the domain of Arts added to it. The activity serves as an example of curriculum development and as a guide to help further development of such activities. This study attempted to provide how math and science curricula can be integrated in a pedagogical knowledge-based framework to show how beneficial and effective is scientific knowledge in real life application if an integrated curriculum is used. The study recommends that increasing the number of integrated math and science methods courses can support primary education teachers in implementing STEAM curriculum within their programs of study.

Contribution/Originality: This study contributes to the existing literature in the field of STEAM Education. The design and the model suggested in this study as well as the underlying conceptual framework can be replicated to suit different activities and in different contexts.

1. INTRODUCTION

The world is rapidly evolving where many subjects are becoming more integrated and connected in several ways. Science, Technology, Engineering, and Mathematics (STEM) education is rapidly becoming of global interest to academics and educationalists around the world (Corlu, Capraro, & Capraro, 2014). School learning environments in the 21st century must not only focus on academic success, but also provide students with upper level skills such as communication, critical thinking, creativity problem solving, and collaboration (Akaygun & Aslan-Tutak, 2016). Historically, the concept of STEM was embedded in business and industry and then was applied in many other arenas, including education. The words of this terminology had been stated clearly for the

first time in the US presidential speech in his State of Union Address on January 25th, 2011 and this mentioning was considered the threshold of STEM (Carnevale, Smith, & Melton, 2011).

According to Siekmann and Korbel (2016) “STEM learning is a multi- or interdisciplinary approach to learning, in which academic concepts are coupled with real-world lessons to make connections between school, community, work and business” (p.17). Gonzalez and Kuenzi (2012) define STEM education as the collective teaching and learning activities across all four subjects, and across the different grade levels. Bybee (2013) defines STEM literacy as “means to develop a capable society in all fields of STEM, including: knowledge, attitudes, and skills to engage in STEM-related issues and with the ideas of science, technology, engineering and mathematics as a constructive, concerned, and reflective citizen” (p. 101). According to Bozkurt, Ucar, Durak, and Idin (2019) STEM can be defined as a method of teaching and learning that combines theory and practice regarding the four named disciplines and real-world hands-on-experiences.

Many politicians and leaders have pointed out the gap between available STEM workers and the numbers of qualified workers needed. This gap can be bridged by producing more degrees in STEM and preparing more high-skilled professionals in STEM related disciplines to minimize this shortage. They realized that not having enough numbers of robust STEM workforces will eventually lead to slowing down the economy and increasing the unemployment rates (Carnevale et al., 2011). Moreover, because more emphasis is being placed on “Global Citizenship” as a key 21st century skill, global economies at all levels are becoming more aware of the need for producing capable global citizens, particularly in STEM skills. This “skills gap” had been identified in the United States, Europe, and many countries around the world; the current educational system is not able to produce individuals with enough STEM skill proficiency to be successful in today’s competitive global economies (Kennedy & Odell, 2014). Globally, STEM became a strong trend in global education as a natural demand based on several research results. This indicates that a high number of students were still not well prepared and needed to acquire professional skills for the current and the future global economy requirements (National Research Council [NRC], 2011).

Sarama et al. (2018) argued that STEM education should start from early childhood as good early STEM education establishes a vital framework for learning about these subjects. If started early, it promotes later learning and gets laid out in the common core next generation international standards for Mathematics Science and innovation in Education. Young learners are intrigued to do experimental things. They enjoy manipulating tools and are curious about the workings of technology. They are interested in engineering activities, and they apply mathematics every day. This makes STEM interesting and relevant for young learners (Pawilen & Yuzon, 2019). Many countries around the world began to implement some form of integration of STEM education into their educational systems such the United States, Turkey, Australia, Singapore, and many European union countries (Corlu et al., 2014). The elementary educational system in the Kingdom of Bahrain is one example in which high-level of global strategies are implemented. The Bahraini Higher Education Council (HEC) emphasized that the success of implementing global educational strategies will be based on the realization of desired results to provide the society with high-qualified graduates as a national objective. Therefore, the HEC works on engaging STEM into the elementary educational system to achieve this objective (Higher Education Council, 2014).

As a revolutionary change, the Arts stream was incorporated as one of the integrated subjects within the STEM education activities in order to naturally produce opportunities in one additional discipline. Several studies have approved of incorporating elements of Arts and calling it integrated STEAM activity. For instance, MacDonald, Hunter, Wise, and Fraser (2019) opine that while STEM and STEAM curricula are very similar and intertwined, it is still extremely important for curriculum developers to first understand the basic premise and principles of STEM education. It is important that important to first understand the case for STEM education and then expand the theoretical framework to include Arts.

The purpose of this study was to identify the potential benefits and capacities offered by introducing an integrated STEAM education program into the primary education curriculum in the Kingdom of Bahrain. The study specifically investigates how an integrated STEAM curriculum could be designed to fit within the requirements of the Ministry of Education (MOE) for primary education. The study will focus on how to transfer from the traditional childhood education to the innovative STEAM education by adding the Arts domain.

1.1. Why STEM Education?

STEM plays an important role in building a stronger foundation of students in terms of acquiring knowledge content, achieving academic skills, and improving their cognitive abilities. STEM helps students to have a high quality of academic attitude and behaviors and pursuing their learning goals. STEM can equip students with the 21st century skills by developing their critical thinking skills and allowing them to solve real-world problems using new constructed knowledge. It enables students to improve their skills in communication, collaboration, self-regulation, and using information and communication technology in their learning (Stehle & Peters-Burton, 2019). STEM can be beneficial as a teaching strategy that increases the students' creativity and innovation skills by providing them with multi-task activities that require high level of mental activities (Achat-Mendes et al., 2019).

In a meta-summary study of qualitative findings about STEM Education, Kanadli (2019) found that, apart from motivation, STEM education enables students to develop positive attitudes, develops a sense of responsibility, increases self-confidence, and raises awareness of both real-life problems and themselves. Moreover, Hudson, English, Dawes, King, and Baker (2015) conducted a study that investigates the links between pedagogical knowledge and skills and students' outcome in STEM education in elementary schools. They concluded that pedagogical knowledge and skills, that include lesson planning and designing assessment, as well as differentiating instruction in STEM related content, improved student achievement in elementary schools using STEM education curriculum and activities. Daugherty, Carter, and Swagerty (2014) argue that elementary school students develop greater enthusiasm and interest in learning engineering, science, and math skills through an integrated STEM curriculum more than they would learn by using a regular curriculum. Furthermore, they argue that in order to support further implementation of STEM curricula at middle and high school levels, it is essential that young children at the elementary level are introduced to STEM curriculum. This will increase their interest and curiosity about STEM fields, thus facilitating future implementation of such curricula at higher grade levels.

STEM methods and STEM activities have shown a huge effect on solutions to challenges of everyday life (Gülen, 2019). As data shows, students are underperforming in science, technology, engineering, and mathematics. Clearly, these four subjects are STEM's four knowledge areas. Besides, research also found students are not engaging successfully in engineering and technology (Stehle & Peters-Burton, 2019).

1.2. Challenges Facing STEM Education

Ejiwale (2013) presented a set of nine challenges that could hinder and act as barriers to the successful implementation of a STEM curriculum. These barriers included the "poor preparation and shortage of supply of qualified STEM teachers" (p. 64). He argued that lack of preparation of STEM teachers could lead to decreased motivation and interest in both teachers and students and therefore could negatively affect the success of a STEM program. Another barrier was "the lack of investment in teachers' professional development" (p.66), which could open doors to bypass teacher preparation program requirements and help train current teachers on the methods and the content knowledge required for successful delivery and implementation of an integrated STEM curriculum.

Studies and field experience showed a low level of motivation from students to study STEM subjects individually and this negatively impacted their learning progress and academic achievement. There is a need to allow students to learn based on their speed and level in these four subjects in order to master their learning and

skills. Teachers need more professional developments in their subjects and teaching strategies, where STEM stands as a perfect opportunity to improve (Ismail, 2018).

Despite the growing desire of shifting to STEM curriculum, there are still some challenges facing this approach. It is more challenging to shift from the normal traditional teaching towards the evidence-based instructional practices. Instructional practices can be different from one subject to another and between students' different levels. Research emphasizes the importance of comprehensively exploring of the contextual factors of each subject before developing curricula that connects between subjects. Creating comprehensive and validated assessment instruments that can systematically and effectively assess STEM outcomes requires massive time and efforts (Sturtevant & Wheeler, 2019).

The educational structure and administrative procedures may interrupt the process of using STEM in teaching. It requires additional fund and technological capabilities to support STEM activities, which are not always available (Achat-Mendes et al., 2019). According to Kanadli (2019) the main limitations of STEM education are that it takes time to prepare and apply, and it is expensive as it requires sufficient equipment and materials. Moreover, the difficulty of preparing and practicing it, the inadequacy of curricula, and the inability to apply it in crowded classes have been identified as the other common limitations of STEM training.

Corlu et al. (2014) conducted a study that investigated the current educational reforms taking place in Turkey with regards to the education of Science, Technology, Engineering and Mathematics (STEM). They mentioned that these reforms faced criticism at the teacher education levels, particularly with regards to whether or not teachers are prepared to teach an integrated STEM curriculum. The study concluded that it was essential for teacher education programs to take into consideration "integrated teaching knowledge" that better prepared and assisted teachers in the transition from a traditional "departmentalized" teaching model to a more "integrated" teaching model. Similarly, Kennedy and Odell (2014) emphasized the importance of preparing teachers for integrated instruction. They argued that integrated instruction is a process that requires prepared teachers, engaged students, and well-designed assessment procedures.

1.3. Promoting STEM Education

Integrated STEM education requires teachers to maintain content knowledge across different subject areas, which creates further requirements at the teacher preparation levels in the process of designing courses that prepare teachers in these content areas. Moreover, teaching an integrated STEM curriculum poses further challenges in the preparation time needed and the design of assessments appropriate for these integrated curricula (Stohlmann, Moore, & Roehrig, 2012). In order to integrate Math and Science instruction, it is essential that teachers acquire the necessary pedagogical knowledge in both subject areas (Hudson et al., 2015; Walker, 2007). Both parents and teachers seem eager and willing to promote early STEM learning, but need additional training and resources to do so effectively. Teachers in early childhood settings need more effective preparation and professional development to engage young children successfully in developmentally appropriate STEM learning (McClure et al., 2017).

Changpetch and Seechaliao (2019) proposed an instructional model based on Science, Technology, Engineering, and Math (STEM) Education approach for enhancing the information and communication technology skills for elementary students in Thailand. The five main elements of this model are principles, purpose, content, teaching and learning process, and measurement and evaluation of ICT skills. From the engineering design process, there are six main steps which consist of problem identification, related information search, solution design, planning and development, testing evaluation, design improvement, and presentation. Pawilen and Yuzon (2019) suggested the following to consider in developing a STEM Curriculum: (1) interests of the students on the topics and activities (2) availability of materials to be used (3) appropriateness of the topics and activities to the learners (4) relevance to learners' daily lives (5) connection of the contents and activities to the k-12 curriculum (5) integration of science, technology, engineering, and mathematics.

According to Pawilen and Yuzon (2019) the criteria for selecting activities for the STEM curriculum include encouraging collaboration among students, providing opportunities for students to plan, design, and experiment, encouraging all students to think creatively and critically, encouraging play-based academic discussion, and , providing fun, exciting, and age appropriate opportunities for children to solve simple problems. As for primary education in Bahrain, the Ministry of Education (MOE) has built a unique curriculum of primary education of math, science, art, and technology subjects separately. It provides teachers with all necessary materials and training programs to be well trained to teach their subjects for primary students. It supervises the schools through a comprehensive program of quality assurance to maintain the high level of teaching quality and effective learning process. In addition to that, Bahrain Teachers College (BTC) at the University of Bahrain (UOB) contributes by teaching primary education subjects of math, science, and technology, by preparing students to be successful teachers and by providing them with all content and pedagogical needs of each subject. These efforts are parallel and supportive to the governmental economical vision of 2030 of Bahrain.

1.4. Theoretical Framework to Design a STEM Curriculum

Researchers have proposed several frameworks for the design and implementation of STEM curricula (English, 2017); those frameworks differ in the degree of integration of different subject areas and in the degree in which certain topics may invoke primary objectives or supporting objectives. Bryan, Moore, Johnson, and Roehrig (2015) identified three different forms of STEM integration:

- “(a) content integration where learning experiences have multiple STEM learning objectives;
- (b) integration of supporting content where one area is addressed (e.g., mathematics) in support of the learning objectives of the main content (e.g., science), and (c) context integration where the context from one discipline is used for the learning objectives 6 from another. While the integration of supporting content is frequent, it appears not to be applied in a way that effectively extends this content” (Bryan et al. (2015), Cited in English (2017), pp 5-6).

Similarly, Kelley and Knowles (2016) proposed an integration framework in which “situated learning, engineering design, scientific inquiry, technological literacy, and mathematical thinking” (p.3) are integrated into one system. The authors emphasize, however, that it is not necessary that all aspects or content areas mentioned in the framework are integrated at each step of the lesson or activity, nonetheless, teachers should have enough content and pedagogical knowledge that enables them to understand the connections between the different disciplines and the ways to integrate them when needed.

Researchers also pose a distinction between an *interdisciplinary curriculum* and a *multidisciplinary curriculum* (Thibaut et al., 2018). In a multidisciplinary curriculum, students are introduced to different concepts from different subjects separately such as Math and Science and are expected to draw on their connections to real-life; while in interdisciplinary curriculum, real-world problems are used to introduce students to several concepts across different subjects in the same classroom and within the same activity (Wang, Moore, Roehrig, & Park, 2011). In the current study, the latter approach was adopted in which an interdisciplinary approach was used to design real-world activities that could integrate concepts from all STEM subject areas.

English (2017) proposed a framework in which the design and analysis of STEM activities was based on the learning objectives at each stage of the lesson or activity. She argues for equitable discipline integration, where students are engaged in solving real-life problems or engaged in integrated STEM activities that cultivate their broad knowledge of all subject areas, yet they still receive the needed disciplinary specific instruction for complete understanding of topics within each area without undermining other disciplines (Pearson, 2017).

El-Deghaidy, Mansour, Alzaghibi, and Alhammad (2016) explained the positive results of teaching science content in support of technology, mathematics, and engineering contexts. This conjunction is found to increase self-

efficacy as well as achieved pedagogical knowledge. It minimizes any interrupting issues while teaching science and provides different assessment strategies. Students can integrate science content in different real-life experiences that are provided through different contexts. It increases students' skills in problem solving, exploring, and innovation.

Similarly, Nelson, Lesseig, and Slavit (2016) highlighted the successful results of mathematical teaching in technology context. Their findings suggest that integration helps students build positive attitudes towards learning mathematical content. It also increases their persistence in solving mathematical problems. This process sparks students' curiosity and willingness to learn by learning from their mistakes and errors. It develops their creative thinking and their ability to work in independent or collaborative environments. They also concluded that the technology context equips students to be innovative in performing mathematical calculations and solving problems.

Cevik (2017) analyzed several studies that focus on teaching mathematics content by using a well-designed science context. This merger of science and mathematics is beneficial for students because it helps them to clearly comprehend the connections among these two disciplines in a meaningful manner. This integrative design increases students' motivation and interest to learn more because they transfer knowledge through practical application. The Science context helps students learn by working on projects as well as develop their mathematical skills in an exploration rich environment.

Asgar, Ellington, Rice, Johnson, and Prime (2012) examined the impact of teaching technology and engineering content within the science context. They found high potential of a positive impact of using science context in enhancing students' problem-based learning experiences. It helps students to develop their perception of new concepts and skills. This integration design encourages students to solve interdisciplinary life problems through active knowledge construction and retention. It enables students to develop creative imaginations and critical thinking, which are crucial in learning technology and engineering.

In their study, Hudson et al. (2015) concluded that pedagogical knowledge is linked to students' learning outcomes. They argued that teachers must possess the needed pedagogical knowledge in each of the STEM disciplines in order to utilize different teaching strategies that ensure students understand the underlying connections between the content in different subject areas. Similarly, English (2017) emphasized pedagogical content knowledge across disciplines and proposed organization of learning objectives based on their priority in the curriculum as well as the class in which they are being taught. For example, at a certain stage in a unit, the primary learning objective could be related to mathematics and sciences, while the technology and engineering learning objectives are considered supporting learning objectives.

This paper utilizes this framework in the design of a STEM activity with different learning objectives that, all together, foster an integrated STEM learning experience.

1.5. Designing an Integrated STEAM Activity

The authors also utilized the previously mentioned theoretical framework as the basis for guiding the design of a STEAM integrated activity that includes objectives from all the five STEAM subjects; Science, Technology, Engineering, Arts and Math. Namely, art can be considered as an important subject in STEAM because it encourages students to develop their creativity skill and improve their ingenuity while they are working on their projects. Students can use Arts to have a better communication skill that has a positive impact on their overall performance (Land, 2013; Segarra, Natalizio, Falkenberg, Pulford, & Raquell, 2018). Each stage of the activity includes primary objectives, as well as supplementary objectives that are also incorporated into the activity.

1.6. The STEAM Activity

Student's age: 10-12 years old.

Material: basin, water, foil paper, ruler, scissor, tape, scale, 100 fils coins.

Strategy: group work.

Stage 1: Students will be investigating how density effects the object floating or sinking in water.

Science Objective: Students will demonstrate understanding of the concept of density.

Math Objective: Students will be able to find different dimensions of similar area shapes.

At this stage, students will be investigating when the foil paper will float and when it will sink. Teacher will be guiding students' work through the following questions:

- Place 30 cm² foil paper on water. Does it float or sink? Why?
- Sink the foil paper in water by your hand, then crumple the foil paper while it is in water. Does it float or not? Why?
- Crumple another 30 cm² foil paper outside the water and then push it inside the water. Does it sink or not? Why?

By the end of the activity students should conclude that if the density of the object is more than the density of the liquid then the object will sink and vice versa. Also, by performing this investigation, students will be practicing a primary content from science and math subjects, while the engineering is playing here a supporting subject role. As student were asked to use a 30 cm² foil paper without mentioning the shape, so the student should decide if it is a 5×6 or 3×10 or 2×15 rectangle or even another shape. So, student should start to build an engineering sense of what is the best shape to be used in the activity. Table 1 shows the mapping of three activities, of stage one namely science, engineering and mathematics in stage one.

Table-1. Stage one mapped against STEAM domains.

STEAM Subjects	Science	Technology	Engineering	Art	Math
STEAM Primary Content	x	-	-	-	x
STEAM Supporting Context	-	-	x	-	-

Stage 2: Students will be investigating Archimedes principle of floating objects.

Science Objective: Students will demonstrate understanding of Archimedes principle.

Math Objective: Students will be able to find the difference in objects mass. Students will be able to solve very basic algebraic equation.

At this stage, students will be investigating Archimedes principle. Teacher will be guiding students through the following steps:

- Make a 30 cm² base triangular boat from the foil paper. Use 2 cm height edge for the dimensions of the boat, then measure the mass of the boat.
- Stick a ruler on the basin and measure the height of the water.
- Place the boat on the water and see how the water level increases, add a number of coins in the boat making sure it won't sink. Then read the height of the water.
- Measure the weight of the coins you placed in the boat and add it to the boat's weight.
- Measure the displaced water by taking it off from the basin, and measuring the centimeters displaced reducing the height of the displaced water.
- What did you find out?

By the end of the activity students should conclude Archimedes principle which says, "Floating objects displace water equal to their own weight". Again, students will be practicing a primary content from the science and math subjects, while the engineering is playing a supporting subject role here which was used as the context of teaching. As student were asked to design a 30 cm² base triangular boat from the foil paper, so the student should decide if it is a 10×6 or 2×30 or 20×3 or 5×12 triangle. So, after the stage one, students should have a better engineering sense of what best dimensions are to be used to perform the activity. They can also use draft drawings to have the

best design, which mean the art was used here as a supporting subject. Table 2 shows the mapping of Stage 2 objectives against the four domains of STEAM, except technology.

Table-2. Stage two mapped against STEAM domains.

STEAM Subjects	Science	Technology	Engineering	Art	Math
STEAM Primary Content	x	-	-		x
STEAM Supporting Context	-	-	x	x	-

Stage 3: Students will be able to find relationship between mass and volume in density by investigating the best boat design which can carry more mass.

Science Objective: Students will demonstrate the effect of mass and volume in density.

Math Objective: Students will be able to find the surface area and volume of different 3D shapes.

Engineering Objective: Students will be demonstrating the ability of designing a boat with specific criteria.

At this stage, students will be investigating the effect of different 3D shapes volume in carrying more mass without floating. Teacher will be guiding students through clear steps and guided questions:

- Use square, circular, triangular, rectangular base boats and check what is the best design if you are using the same area for the base shape? You can combine different base shapes.
- In an excel sheet record the area of the base, the volume, shapes you were using and count the number of coins each shape can carry before floating.
- What is the best shape and volume to hold as many coins as possible without sinking?

By the end of the activity, students should conclude the best base shape that can carry more coins and try to find the relationship between the shape and the volume. Students will be practicing primary content from math, science and engineering, as the design of the boat in this stage is a primary knowledge, while Arts will be the context the students will be working around, through creating the boat design and choosing its colors. In order to finalize the shape, technology here will be supporting to organized the data. Table 3 shows the mapping of Stage three objectives with all the five STEAM domains.

Table-3. Stage three mapped against STEAM domains.

STEAM Subjects	Science	Technology	Engineering	Art	Math
STEAM Primary Content	x	-	x	-	x
STEAM Supporting Context	-	x	-	x	-

Stage 4: Students will be reflecting on the effect of an inquiry-based activity in their learning.

Art Objective: Students will be writing reflective essay about Archimedes principle and about their experience of designing the boat.

ICT (Technology) Objective: Students will be typing their essay and use Paint program to draw their boat with its dimensions.

In this stage, students will begin by writing a reflective essay about their learning and how they felt about this experiment and learnt each steam subject while doing the activity. Teacher will be guiding students' work through the following steps:

- Write 500-word essay about the learning you gained from the investigation you did.
- Make sure to use reflective action verbs while expressing the learning you went through.
- Use Times New Roman Font Size 12 with single line spacing and page margins of 2 (Top, Bottom, Left, Right).
- Use paint or 3D paint programs to draw the structure and dimension of your boat, and label all the sides lengths.

By the end of the activity, students need to use their ICT knowledge of typing and drawing and their literacy knowledge of reflective writing as their primary content, while the math, science and engineering will be their context which writing and drawing about the experiment. Table 4 shows the mapping of the fourth stage objectives with the five STEAM domains.

Table-4. Stage four mapped against STEAM domains.

STEAM Subjects	Science	Technology	Engineering	Art	Math
STEAM Primary Content	-	x	-	x	-
STEAM Supporting Context	x	-	x	-	x

2. DISCUSSION

Curriculum developers and educators face several difficulties when developing lessons or activities for a STEM or a STEAM-based curriculum. One of the main difficulties is having to align objectives from different disciplines, such as math, science, technology, art, and engineering into one lesson or one activity. In this activity, the current authors developed the activity with an approach that attempted to divide learning objectives at each stage in the activity (English, 2017). Table 1 to Table 4 show the mapping of the learning objectives from each stage with the domains of STEAM at two levels: Primary Content and Supporting Context. As per the framework proposed by English (2017) an objective is considered primary when direct instruction related to that objective is apparent in the activity. However, if the activity, at a certain stage, involves objectives that are not substantially evident and no direct instruction needs to be provided by the teacher for that objective, then it is classified under Supporting Context.

Researchers have argued that implementing a STEM curriculum might require additional teacher training in order to prepare teachers that are well-trained in teaching an integrated curriculum (Stohlmann et al., 2012). However, if such design approaches are used, it can reduce the need for training teachers to teach in different disciplines; The obvious example is primary level teachers who are capable of teaching the material and guiding students through these activities without the need for any additional training in different fields.

Nonetheless, one way to support elementary teachers in their efforts of implementing STEM curriculum is by increasing the number of integrated Math and Science methods courses within their programs of study; Daugherty et al. (2014) argued that a teacher-preparation program of study where math and science methods courses are integrated could significantly enhance elementary teachers' dispositions and abilities in teaching a STEM curriculum.

3. CONCLUSION AND RECOMMENDATIONS

The purpose of this article was to demonstrate a sample activity for primary students that incorporates all the elements of STEM education. Moreover, the article shows a systematic approach to evaluating and designing activities that cover different subjects at different stages within the activity. A great deal of interest is being placed on the development of STEM and STEAM curriculum; in fact, according to Daugherty et al. (2014) the U.S has allocated more than \$250-Million dollars in funds to train more STEM teachers and advance this STEM movement. This further illustrates the importance of more research on the best practices for incorporating STEAM fields into the current curriculum and, thus, equipping students with the needed skills for success in the 21st century. Further research can explore possibilities of designing interdisciplinary units that can meet STEAM requirements, and simultaneously reduce the need for large scale training of STEAM teachers that are capable of teaching all subjects in the same classes.

Funding: This study received no specific financial support.

Competing Interests: The authors declare that they have no competing interests.

Acknowledgement: All authors contributed equally to the conception and design of the study.

REFERENCES

- Achat-Mendes, C., Anfuso, C., Johnson, C., Shepler, B., Hurst-Kennedy, J., Pinzon, K., & Sudduth, E. (2019). Learning, leaders, and STEM skills: Adaptation of the supplemental instruction model to improve STEM success and build transferable skills in undergraduate courses and beyond. *Journal of STEM Education: Innovations and Research*, 20(2), 14-23.
- Akaygun, S., & Aslan-Tutak, F. (2016). STEM images revealing stem conceptions of pre-service chemistry and mathematics teachers. *International Journal of Education in Mathematics, Science and Technology*, 4(1), 56-71. Available at: <https://doi.org/10.18404/ijemst.44833>.
- Asghar, A., Ellington, R., Rice, E., Johnson, F., & Prime, G. M. (2012). Supporting STEM education in secondary science contexts. *Interdisciplinary Journal of Problem-based Learning*, 6(2), 85-125. Available at: <https://doi.org/10.7771/1541-5015.1349>.
- Bozkurt, A., Ucar, H., Durak, G., & Idin, S. (2019). The current state of the art in STEM research: A systematic review study. *Cypriot Journal of Educational Sciences*, 14(3), 374-383. Available at: <https://doi.org/10.18844/cjes.v14i3.3447>.
- Bryan, L. A., Moore, T. J., Johnson, C. C., & Roehrig, G. H. (2015). Integrated STEM education. *STEM Road Map: A Framework for Integrated STEM Education*, 23-37.
- Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. Arlington: NSTA Press.
- Carnevale, A. P., Smith, N., & Melton, M. (2011). Stem: Science technology engineering mathematics. Georgetown University Center on Education and the Workforce.
- Cevik, M. (2017). Content analysis of stem-focused education research in Turkey. *Journal of Turkish Science Education*, 14(2), 12-26.
- Changpetch, S., & Seechaliao, T. (2019). The propose of an instructional model based on STEM education approach for enhancing the information and communication technology skills for elementary students in Thailand. *International Education Studies*, 13(1), 69. Available at: <https://doi.org/10.5539/ies.v13n1p69>.
- Corlu, M. S., Capraro, R. M., & Capraro, M. M. (2014). Introducing STEM education: Implications for educating our teachers in the age of innovation. *Education and Science*, 39(171), 74-85.
- Daugherty, M. K., Carter, V., & Swagerty, L. (2014). Elementary STEM education: The future for technology and engineering education? *Journal of STEM Teacher Education*, 49(1), 7. Available at: <https://doi.org/10.30707/jste49.1daugherty>.
- Ejiwale, J. A. (2013). Barriers to successful implementation of STEM education. *Journal of Education and Learning*, 7(2), 63-74. Available at: <https://doi.org/10.11591/edulearn.v7i2.220>.
- El-Deghaidy, H., Mansour, N., Alzaghibi, M., & Alhammad, K. (2016). Context of STEM integration in schools: Views from in-service science teachers. *EURASIA Journal of Mathematics Science and Technology Education*, 13(6), 2459-2484. Available at: [10.12973/eurasia.2017.01235a](https://doi.org/10.12973/eurasia.2017.01235a).
- English, L. D. (2017). Advancing elementary and middle school STEM education. *International Journal of Science and Mathematics Education*, 15(1), 5-24. Available at: <https://doi.org/10.1007/s10763-017-9802-x>.
- Gonzalez, H. B., & Kuenzi, J. J. (2012). *Science, technology, engineering, and mathematics (STEM) education: A primer*. Paper presented at the Washington, DC: Congressional Research Service, Library of Congress.
- Gülen, S. (2019). The effect of STEM roles on the solution of daily life problems. *Participatory Educational Research*, 6(2), 37-50. Available at: <https://doi.org/10.17275/per.19.11.6.2>.
- Higher Education Council. (2014). *National higher education strategy. Putting higher education at the heart of the nation (2014-2024)*. Kingdom of Bahrain: Ministry of Education.
- Hudson, P., English, L., Dawes, L., King, D., & Baker, S. (2015). Exploring links between pedagogical knowledge practices and student outcomes in STEM education for primary schools. *Australian Journal of Teacher Education*, 40(6), 134-151. Available at: <https://doi.org/10.14221/ajte.2015v40n6.8>.
- Ismail, Z. (2018). *Benefits of STEM education. K4D Helpdesk Report*. UK: International Development Department.
- Kanadli, S. (2019). A meta-summary of qualitative findings about STEM education. *International Journal of Instruction*, 12(1), 959-976. Available at: <https://doi.org/10.29333/iji.2019.12162a>.

- Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3(1), 1-11. Available at: <https://doi.org/10.1186/s40594-016-0046-z>.
- Kennedy, T., & Odell, M. (2014). Engaging students in STEM education. *Science Education International*, 25(3), 246-258.
- Land, M. H. (2013). Full STEAM ahead: The benefits of integrating the arts into STEM. *Procedia Computer Science*, 20, 547-552. Available at: <https://doi.org/10.1016/j.procs.2013.09.317>.
- MacDonald, A., Hunter, J., Wise, K., & Fraser, S. (2019). STEM and STEAM and the spaces between: An overview of education agendas pertaining to 'disciplinarity' across three Australian states. *Journal of Research in STEM Education*, 5(1), 75-92. Available at: <https://doi.org/10.51355/jstem.2019.64>.
- McClure, E. R., Guernsey, L., Clements, D. H., Bales, S. N., Nichols, J., Kendall-Taylor, N., & Levine, M. H. (2017). STEM starts early: Grounding science, technology, engineering, and math education in early childhood. New York: The Joan Ganz Cooney Center at Sesame Workshop.
- National Research Council [NRC]. (2011). *Successful K-12 STEM education: identifying effective approaches in science, technology, engineering, and mathematics*. Washington, DC: National Academies Press.
- Nelson, T. H., Lesseig, K., & Slavitt, D. (2016). *Making sense of "STEM education" in K-12 context*. Paper presented at the NARST International Conference Baltimore, MD.
- Pawilen, G. T., & Yuzon, M. R. A. (2019). Planning a science, technology, engineering, and Mathematics (STEM) curriculum for young children: A collaborative project for pre-service teacher education students. *International Journal of Curriculum and Instruction*, 11(2), 130-146.
- Pearson, G. (2017). National academies piece on integrated STEM. *The Journal of Educational Research*, 110(3), 224- 226. Available at: <https://doi.org/10.1080/00220671.2017.1289781>.
- Sarama, J., Clements, D., Nielsen, N., Blanton, M., Romance, N., Hoover, M., . . . McCulloch, C. (2018). *Considerations for STEM education from PreK through grade 3*. Waltham, MA: Education Development Center, Inc.
- Segarra, V. A., Natalizio, B., Falkenberg, C. V., Pulford, S., & Raquell, M. H. (2018). STEAM: Using the arts to train well-rounded and creative scientists. *Journal of Microbiology and Biology Education*, 19(1), 1-7. Available at: <https://doi.org/10.1128/jmbe.v19i1.1360>.
- Siekman, G., & Korbil, P. (2016). *Defining 'STEM' skills: Review and synthesis of the literature — support document 2, NCVET*. Adelaide: National Centre for Vocational Education Research.
- Stehle, S. M., & Peters-Burton, E. E. (2019). Developing student 21 st century skills in selected exemplary inclusive STEM high schools. *International Journal of STEM Education*, 6(1), 1-15. Available at: <https://doi.org/10.1186/s40594-019-0192-1>.
- Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research*, 2(1), 28-34. Available at: <https://doi.org/10.5703/1288284314653>.
- Sturtevant, H., & Wheeler, L. (2019). The STEM faculty instructional barriers and identity survey (FIBIS): Development and exploratory results. *International Journal of STEM Education*, 6(1), 35. Available at: <https://doi.org/10.1186/s40594-019-0185-0>.
- Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., & De Cock, M. (2018). Integrated STEM education: A systematic review of instructional practices in secondary education. *European Journal of STEM Education*, 3(1), 1-12. Available at: <https://doi.org/10.20897/ejsteme/85525>.
- Walker, E. N. (2007). Rethinking professional development for elementary mathematics eachers. *Teacher Education Quarterly*, 34(3), 113-134.
- 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*, 1(2), 1-13.

Views and opinions expressed in this article are the views and opinions of the author(s), International Journal of Education and Practice shall not be responsible or answerable for any loss, damage or liability etc. caused in relation to/arising out of the use of the content.