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Transforming the teaching of early years Science and Mathematics through the integration of STEAM education: What in-service teachers think?

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ABSTRACT- This study investigated the change in perceptions of pre-service teachers about integrating STEAM education to transform the teaching of Science and Math. The study adopted a qualitative exploratory approach and utilized semi-structured interviews to investigate what the participants experienced and thought. The 8 participants are currently enrolled in a 1- Year Post Graduate Diploma in Early Childhood Education program in an urban university of Lahore, Pakistan. They were taught to integrate STEAM Education in the teaching of different subjects including Science and Math in the early years and elementary level. The resulting 5 themes highlighted issues like an acknowledgement of the gap between the teachers' perceptions and actual practices of STEAM education (resultant lack of expertise); lack of optimism regarding the implementation of STEAM at the school level; development of deeper knowledge of Maths and Science with the Incorporation of STEAM Concepts; increase in Sense of Agency through STEAM Education practices, and need to educate school administration in STEAM Education. The results may be used to better reflect on STEAM integration policies and decisions in future within elementary education in Pakistan.

Keywords: STEAM Education, teaching pedagogy, Teacher Professional Development, Early childhood education, Science Education, Mathematics Education

I. INTRODUCTION

The 21st century is the era where the teaching and learning of subjects related to science and technology have become a priority in educational programs all over the world (Kelley & Knowles, 2016). There is a need to teach students how to address global issues and problem solving by strengthening them in areas related to engineering, science and technology (ibid.). This can be made possible by offering opportunities of developing 21st-century skills to the students, and prospective teachers alike. Integration of the subjects in STEAM will help prepare a STEAM literate society, capable of reflecting and solving STEM issues as a reflective, global citizen(Bybee, 2013; Erdogan & Ciftci, 2017). These skills involve critical thinking, collaborative and leadership skills, problem-solving and negotiation skills, analytical skills, curiosity and original thinking, the ability for effective oral and written communication well as inter and intrapersonal skills (Wagner, 2008; Stehle & Peter-Burton, 2019).

There have been many interventions to integrate STEM and STEAM (science, technology, engineering, arts and mathematics) within the educational policies in advanced countries (Kang, 2019). In the United States of America, the Next Generation Science Standards (NGSS) use engineering design and practices in elementary education the NGSS Lead States, 2013, (as cited in Bybee, 2014). Similarly, in the United Kingdom, STEM learning has been promoted in the policy agenda for education within and outside schools (STEM Learning, 2018).

STEM education in Pakistan is yet to achieve its full potential (Hali, Aslam, Zhang & Saleem, 2021). Some issues highlighted by them are teaching competencies, poor syllabus of STEM education, untrained teachers and lack of market-oriented jobs. They also emphasize that the role of the public sector and government is less than that of the private sector, mainly due to lack of resources, equipment and laboratories. There is a need to train and educate teachers in the implementation of STEAM in early year education. This study aimed to address this issue by integrating STEAM within the Methods of Teaching Course taught to pre-service student teachers who have completed their BS (4 years) in various disciplines.

II. REVIEW OF LITERATURE

The concept of STEAM has emerged from STEM (science, technology, engineering, and mathematics), with the inclusion of arts in its focus. The arts encompass 'fine arts, language arts, liberal arts, and physical arts' (Kang, 2019). It emphasizes the importance of integrated and multi-disciplinary teaching and learning across these disciplines, starting from early years to postgraduate classes (An, 2017; Burton, 2019; Gonzalez & Kuenzi, 2012;Madden et.al. 2013; Marmon, 2019; Quigley, Herro, & Jamil, 2017). It also emphasizes an alignment in "curriculum, instruction and assessment" (Bybee, 2014).

Features of STEM and STEAM Education

It is articulated by Bybee (2010), students' understanding of how things work and how to use their understanding to solve problems and improve the use of technologies can be improved by implementing STEM education in its true sense. He further said:

"STEM education should also introduce more engineering during pre-college education. Engineering is directly involved in problem solving and innovation, two themes with high priorities on every nation's agenda…. The creation of high-quality, integrated instruction and materials, as well as the placement of problems associated with grand challenges of society at the centre of study." (p. 996)

STEAM education aspires that learners will have increased motivation, meaningful learning experiences, find pleasure in learning and will also be inclined towards self-directed learning as a result of integrating the different disciplines (Bae et al.2013; Park et al., 2012; Guimarães, 2019). Three core components lie at the heart of STEAM education: (a) creative design, (b) emotional touch, and (c) convergence and integration of contents (Baek et al., 2011;Hong,2017).

Creative design encompasses the entire process which a learner encounters and passes through to successfully exhibit "creativity, efficiency, and an economic and aesthetic sense to find the optimal solution to a problem" (Park et al, 2016). It comprises the engineering concept which refers to a technological design, and an original approach towards problem-solving, which denotes the shared values of humanity (Park et al, 2016).

When defining creative design, several researchers have referred to it as open-mindedness and teamwork (Householder & Hailey, 2012). Open-mindedness allows students to think out of the box, use their imagination and reflect on the processes. Working in groups paves the way for improved, focused and clear communication to carry out the task efficiently. It also provides students with opportunities to demonstrate self-directed learning till the completion of the task(Park et al, 2016). Emotional touch comprises the entire set of experiences that facilitate self-directed learning, in which students feel interested, improved confidence, a sense of accomplishment and intellectual contentment as they experience fruitful and meaningful learning. They are filled with passion for learning and exploring and construct meaning from their learning. It also involves the actual connection between the learner and the subject, where the subject takes on a personal objective. These elements are generally ignored in education (Park et al, 2016).

Challenges in Implementing STEAM Education: International Research

A huge challenge faced while implementing STEAM education is the readiness of the teachers.Over the years extensive research has been conducted regarding teachers' perceptions and their practices of STEAM education in different contexts (Shin & Han, 2011; Han & Lee, 2012; Lee, Park, & Kim, 2013; Lim & Oh, 2015;). These studies have reported that most of the teachers hold the view that STEAM education is a necessity (Han & Lee, 2012; Lim & Oh, 2015), and also hold the view that STEAM education would have a positive impact on students' motivation and learning (Lee, Park, & Kim, 2013; Lim & Oh, 2015). However, some research found a significant gap between teachers' perceptions and actual practices of STEAM education. One such study by Shin (2013) on 987 Korean elementary and secondary school teachers, found that although the majority of (about 65%) agreed on the necessity of STEAM education, only about 18% took the lead andinitiated STEAM lessons in their class.

Studies regarding teachers experiences and challenges while implementing STEAM education report the major hurdles such as lesson planning as time-consuming and cumbersome, challenges due to lack of relevant instructional material and lack of expertise and confidence in STEAM education (Han & Lee, 2012; Lee, Park, & Kim, 2013; Lim & Oh, 2015; Shin, 2013). Lack of understanding of cross-disciplinary connections in STEAM, and difficulty in working in teams or cooperating with other teachers, have also been cited as challenges (Noh & Paik, 2014).

Training Teachers through STEAM Education

Iqbal and Mahmood (2000) while tracing the history of science education in Pakistan highlight that not only was science excluded from the British curriculum at the time of the inception of Pakistan, it was introduced much later first to the higher classes and then to the lower level. In primary and middle

schools, the subject was introduced in the 1950s, with the earlier focus being on the 3Rs (Reading, writing and arithmetic). The first time science was given its due place in the policy and curricula was in the National policy of 1979. In these circumstances, science teacher education was an even more neglected area. Even in the present scenario, science education is compulsory in primary and middle schools, but optional in Secondary schools (ibid).

In the present scenario, STEM education has gained momentum globally, particularly in "the developed countries like the United States, United Kingdom, Australia, Canada, Finland, and Switzerland have invested heavily in STEM education reform"(Anwar, 2017, p. 21). It is asserted that through investing in STEM education we would be able to achieve vocational and economic goals (Williams 2011) and also prepare students to meet the demands of the future by making them adaptable, creative and problem solvers (Bybee, 2010).

Literature reveals that there is very little research available on the preparation and training of teachers concerning their knowledge and skills of STEAM education (An, 2017; Brown, 2012; Scott, 2012; Stohlmann et.al., 2012). Teachers are the core element for the success of any instructional element. Therefore equipping them with the necessary knowledge and skills is crucial. This has also been addressed by DiFrancesca and associates (2014) who observed that elementary school teachers lack STEM experience and consequently are unable to deliver the concept in their lessons. Furthermore, the lack of experience and know-how can make a teacher less confident, and thus hesitant to try new methodologies and technologies in their teaching **(**Stohlmann et.al., 2012;Wu and An, 2015). To make their STEAM teaching effective, and to support the needs of the learners, teachers need to be familiar with the various technologies, tools and materials, as well as the pedagogical content knowledge and cross-curricular connections (An, 2017; Carnevale et al., 2011).

Making teachers aware about cross-curricular connections helps in the development of "creativity and innovation, communication and collaboration, research andinformation fluency, critical thinking, problem-solving, decision-making, digital citizenshipand technology operators and concept" as elaborated by (Vockley, 2007, Stehle & Peter-Burton, 2019). They also need rich resources and instructional materials with an opportunity of positive STEM experiences to be a success in STEM integration (Peters-Burton, Peters & Remold 2019; Stohlmann et.al. 2012).

III. METHODS

Research Approach

The current study adopted the qualitative exploratory approach for the collection and analysis of data. The qualitative exploratory approach is used when, "not much has been written about the topic or the population being studied, and the researcher seeks to listen to participants and build an understanding based on what is heard" (Creswell, 2017, p. 61). This approach was suitable because there is a dearth of research on the perceptions and voices of in-service Pakistani teachers in the field of STEAM Education.

Participants

The research participants were selected as an intact group of in-service teachers, who have enrolled in the 1-year Post-Graduate Diploma in Early Childhood Education Program at a leading women university in Lahore, Pakistan. The 8 participant teachers were female and had diverse experience in teaching in different public and private sector schools. They have assigned pseudonyms to protect their anonymity. Table 1 shows the demographic information and details about the participants.

Table 1: *Demographic Information of Research Participants*

No.	Pseudonym	Age	Years in Experience	Subjects taught	Grades taught	School
1	Sana	25	1	Languages, Science	2	Private
2	Hina	33	5	G. Knowledge, Social Studies	1	Public
3	Aisha	26	3	Math, Science	Kindergarten	Private
4	Nadia	28	4	Science	1	Public
5	Huda	27	2	Languages, Science	Kindergarten	Private
6	Rida	32	7	Languages, Math	Kindergarten	Private
7	Tahira	28	3	Languages, Science	1	Private
8	Zara	35	7	English Language	2	Public

The experience of the participants ranged from 1 to 7 years as early years teachers. The teachers were teaching many different subjects at the Kindergarten, Grade 1 and Grade 2 level. The participation of the participants was voluntary, based on their experience regarding STEAM Education. They were assured that all interview data would be used for research purposes only. The names of their schools were kept confidential at their request.

Features of STEAM Pedagogy Module

The research participants were taught through a 3 credit- hour STEAM Pedagogy module within their diploma program. The module was based on hands-on techniques and strategies for differentiated instruction, cooperative learning, teaching numeracy and using STEAM as an approach for using Science, Technology, Engineering, the Arts and Mathematics to guide student inquiry, dialogue, and critical thinking. For 16 weeks, the teachers were made to participate in multiple STEAM design challenges and projects, the completion of which contributed to their summative assessment. Some of the STEAM challenges included constructing desktops catapults, making a robotic arm with strings, developing a spider web and engineering marshmallow towers. These challenges were adapted and completed according to the concepts taught in early years concepts and the cognitive levels of the learners.

Data Collection and Analysis

Data was collected by developing an interview protocol for semi-structured interviews. The use of semi-structured interviews allowed participants to relate their experiences, perspectives and takeaways from the STEAM Pedagogy module they had been taught within their diploma program. The questions related to aspects such as the relevance of STEAM concepts and design thinking to the early years Math and Science; appropriacy of application of STEAM education in the early year classroom; nature of knowledge acquisition and concept development through STEAM education; flexibility and innovation through STEAM integration; student and teacher agency; comparison of traditional Math and Science pedagogy and STEAM education; Limitations and constraints in school application; and availability of resources and support materials for implementation.

The interviews were recorded with the permission of the participants. They were later transcribed and translated into English where necessary. The data were inductively analysed for themes and recurrent patterns by employing the Miles and Huberman framework for analysis (2020). The themes were then shared with the research participants for verification and member checking (Creswell, 2017).

IV. RESULTS

Inductive analysis of the interview data highlighted five clear themes in the answers of the research participants. These themes are explained in detail in the subsequent sections: the themes related to 1) Acknowledgement of the gap between the teachers' perceptions and actual practices of STEAM education (resultant lack of expertise); 2) Lack of optimism regarding the implementation of STEAM at school level; 3) Development of deeper knowledge of Maths and Science with the Incorporation of STEAM Concepts; 4) Increase in Sense of Agency through STEAM Education practices, and 5) Need to educate school administration in STEAM Education. The themes are presented below with participant testimonies to better understand the perspectives and experiences of the in-service teachers regarding STEAM education in Pakistan.

Theme 1: Acknowledgement of the gap between the teachers' perceptions and actual practices of STEAM Education

The research participants were not initially aware of what entailed within STEAM pedagogy and thought it was some advanced method that would not be immediately relevant to their practices. The teachers who were already teaching math and science in the early year grades thought that it would not be possible to find a common ground between what they taught in the schools and what concepts were addressed within the STEAM. Sana and Aisha were vocal at the beginning that what they perceived about STEAM education was not how it was practised. They share that they were apprehensive when they were taught about design thinking and how to implement it at the school level. Tahira said, "our understanding truly developed when we completed the 2nd design challenge in the module. Working with our hands and creating the model helped in trying to match the math and science concepts found in the textbooks".

Huda is a relevantly new teacher in a private school. She said that she was somewhat aware of the name STEM or STEAM and always thought it was something one did at the university or college level. He connected STEAM pedagogy with electrical engineering and electronics in an advanced course, and said, "I thought it was like rocket science, and not accessible in Pakistan at all". Nadia also acknowledged that she had no idea about what STEAM is, and was very nervous when the training module began. She acknowledges that she had her cousin for help at the beginning; she had asked him to help her complete

the projects, as he was in pre-engineering at the time. Upon beginning the hands-on work and applying design thinking, she found the fit of STEAM practices and pedagogy an 'organic and natural fit' with the early grades math, science and even arts concepts.

The participants, who primarily handle language education in their schools, believed that STEAM education did not apply to their subjects. Participants like Sana and Zara later changed through views and said that the integration of STEAM education in the language classrooms is an applicable solution. They thought that language teaching and vocabulary development happens best when it is integrated with real-life or context-specific tasks and exposure. They were confident that the student experiential learning which was the focus of STEM education, would enable the young learners to connect the different vocabulary word with actual usage, especially when they will be required to communicate and discuss their work with their peers. In this manner, it can be seen that all participants were in agreement that there was an initial gap between what they had perceived STEAM to be, and what they learnt in light of their training experience within the diploma module. They also emphasized that only a theoretical explanation of STEAM Education practices would not have been enough to make them realize their gap in understanding; learning by dong and a project-based approach was key in making them learn the essence of STEAM practices.

Theme 2: Lack of optimism regarding real implementation of STEAM at the school level

The research participants shared initial scepticism and reservations when they began training in the STEAM pedagogy module. They were in accord that such training was often not designed to be implemented in the actual classroom setup in Pakistan. Hina, who has been working in the public sector for the past 5 years, is convinced that her school would not make provisions or allowance to integrate STEAM Education in her own classroom. She said that although there may talk at the administrative level about the need for teacher training and updating the school practices when it came to doing something, the immediate coordinators and grade class teachers were inflexible and wanted all section teachers to work in a similar manner.

Nadia was of a similar view and said that often the resources available to them and the space provided was not conducive to the STEAM pedagogy group setting. She said that her classroom furniture, which consisted of slanted workbenches for a pair seating, would not allow fir working on projects within the classroom.She was quite clear that she would not be able to practice what she had learned in her school. She was willing to verbally share the learning points with her peers, and integrate the theoretical aspects in her teaching, but practical implementation was not possible. She believed that she could initiate the conversation in her school, which would maybe lead to changes and more support in the future.

Aisha and Tahira, who work in private schools, shared their experience of working on science competitions in the past; they said that the parents and teachers were not willing to make students work on something other than the textbooks. Aisha said that when she asked students to bring some recycled resources from their homes, the parents outright refused that it was a waste of their children's time. Some of them came to see the principal and say that they wanted the teachers to focus on the reading and writing activities only. Tahira said, "a mother came and said they could not let their kids waste time if different art activities or project work were assigned, as it was also a waste of their money".

Zara, an English language teacher, opined that it was not the school culture to allow children to think freely or propose possible solutions or opinions through design thinking. She said it would be a major challenge to make children and other teachers understand the need for student input and allow them the space to make mistakes and learn from peer consultation and/or self-correction. She further shared that it was the school culture to deduct marks for each mistake, making the students less willing to risk a wrong answer; the entire culture would need to be re-interpreted if STEAM was implemented in the early grades.

Theme 3: Development of deeper knowledge of Maths and Science Concepts and Pedagogy

The research participants shared their surprise and initial shock when they discovered that it was not very difficult to master STEAM concepts. Even English language teachers found out they were capable of completing science and math-related projects easily. Rida, who has been a languages Math teacher in a private sector school for the past seven years, shared that, "I have been using English and Maths together to teach math concepts for the past several years. When teaching shapes I have difficulty in student remembering the difference between squares, hexagons, heptagons and octagons. Now, I can teach them these shapes by singing the spider web challenge. I feel they will develop a more clear knowledge of the differences in shapes and how they are found in nature around them".

Hina and Nadia, who teach general knowledge and science in public sector schools respectively, said that they felt that after completing the design challenges, they developed a much more clear

understanding of not only the learningconcept but also how to present it to the students when teaching. They shared that sometimes teachers take some form of world knowledge for granted, and do not realize that students may not have the same prerequisite understanding of how things work. For example, when completing the marshmallow towers and bridges challenge, the participants discovered that they first needed to make the bases of the bridge towers wider and then connect the bridge; otherwise, the bridge titled to one side. This is a basic concept about stabilizing the centre of gravity of an object which is difficult to teach theoretically. This concept helps students better understand their body movement control too. For instance, Hina pointed out that when teaching students to stand in a moving vehicle or a skateboard, it was important to make them widen their stance to stabilize their canter of gravity. They thought they would be better able to demonstrate the concept through STEAM education.

Besides, the hands-on training made teachers modify and adapt their lesson plans for each teaching unit. They were able to grasp where their young students may encounter problems or obstacles. They were able to develop their lesson organization and sequencing skills while completing design projects. They identified the prerequisites and background knowledge that needed to be activated before presenting a new challenge.

Theme 4: Increase in Sense of Agency through STEAM Education practices

The research participants shared their surprise and pride in discovering their sense of agency as a learner and as a teacher during the STEAM pedagogy module. Experienced teachers like Zara and Hina did not think themselves to be very innovative in hands-on projects. They discovered that given the right cues and prompts they could be very creative problem solvers and could translate their mental ideas into a real-life object well. Aisha said, "we are quite used to using our creativity in making math and science concepts interesting. But learning these concepts in a new manner through STEAM education gave us a new perspective of our creative ability". Huda said that she was always good at visualizing, but did not know that practically building something she had visualized would give her such a sense of accomplishment. She believed that completing STEAM projects with the collaboration of her peers boosted her confidence and improved her self-image. She also said that the experience had also reduced the fear she sometimes had that she would forget a learning concept in class.

The language teachers who participated in the STEAM module also agreed that STEAM education improved their self-image and confidence as teachers. Sana and Rida worked in a pair in a project and said initially they were sure they would fail as their main teaching area was language, but they were sometimes asked to teach math or science courses. As language teachers, they said that learning by doing and hands-on learning could aid their mastery of scientific concepts. They thought that they would have to memorize or retain less information due to developing a more in-depth understanding after project completion. Tahira said she felt that she "could take more risks as a teacher and try out new things in class. I think that this module has made me realize that there is a learning opportunity in everyday materials we have. We can teach new concepts through ordinary tasks and objects". This increased teacher agency and confidence is in line with international research and is one of the main pros of integrating STEAM education at the school level.

Theme 5: Need to educate school administration in STEAM Education

The research participants unanimously pointed out that all STEAM training and practices would fail if the school administration was not on board. They stressed that there is a real need to educate and train school administrators, principals and coordinators about the applicability, need and positive outcomes of STEAM education in early grade teaching. The teachers from the private sector schools said that the private schools liked to pick up and market catch-phrases and the newest 'in' terminologies when marketing their schools; in reality, they often lacked the understanding, appreciation or the practical implications of using these with students in real life.

The participants working in public school shared their reservations about the willingness of the older administration to adapt their school practices based on STEAM pedagogy. Nadia said that the school science labs were often lacking in resources and it was not an accepted practice to ask students to bring resources from their home. She shared that her students belonged to families with very low socioeconomic status; although it was practical and possible to ask them to bring discarded or recycled objects, she felt the administration would not agree to it. Aisha said that she has come to realize that even kindergarten students are very resourceful and can work on STEAM projects, but her administration has a certain vision that all kindergarten students need to be spoon-fed. In making the environment safe for them, they are usually handled with extreme care and are not allowed to experiment with anything. In Aisha's opinion, this philosophy needs to be changed and can only be top-down in her school.

Hina pointed out that another misconception in her school is that all hands-on activities are essentially wasting students' time. The administration views teachers who can make students do a lot of physical activities with disfavour. She said the administration needs to be made aware that each step of the STEAM project is a carefully planned out pedagogical intervention with t specific learning objective and purpose, and the teacher is essentially disseminating a lot of learning during supervision of the tasks. Unless this is understood and embraced by the administration, the teachers will not be able to successfully implement or integrate STEAM pedagogy in their classes.

V. DISCUSSION AND CONCLUSIONS

The above themes have pointed out some reservations, current issues and practical implication of teaching through the integration of STEAM pedagogy in elementary and early year grades. As highlighted in Theme 1, the participant teachers were not completely aware of what entailed and consisted of teaching through STEAM or integration of STEAM in the existing curricula. This is in line with the research findings of research by An (2017) and the work done by DiFrancesca and associates (2014). These studies have pointed out how lack of STEAM knowledge and expertise lead to less confidence in teachers. They are reluctant and hesitant in trying to incorporate STEAM in their daily teaching (Stohlmann et.al., 2012; Wu and An, 2015). This was especially true in the case of the language teachers who were a part of this study. They later shared that their perspective and level of understanding about STEAM increased exponentially after completion of the diploma program. They also said that they were more inclined to explore the possibility of STEAM integration in the language classrooms.

This directly ties in with Theme 4 in the present study, which pointed out that the participant teachers felt more in control and experiences an increase in their sense of agency and confidence. The participants acknowledged that the hands-on and practical experience of planning and completing tasks in STEAM education helped them become more familiar with what can and cannot be done through the integration of STEAM pedagogy, a sentiment reflected in the work of Carnevale and colleagues (2011). Teaching through STEAM also tapped into the creative and innovative abilities of the elementary teachers, leading to self-affirmation and a boost in self-image.

They shared that previously they had not considered themselves competent enough to employ such critical thinking and problem-solving skills. Research over the years has pointed out how STEAM not only engages learner creativity and problem-solving skills but also asks them to work through communication and collaboration (Stehle & Peter-Burton, 2019). Hence, STEAM integration in the elementary classes may pave way for making teachers action researchers and adept at creatively using information fluency within their schools and classrooms.

Another serious issue pointed out by the participants was the lack of optimism concerning finding the right types of support, resources and settings that would promote the integration of STEAM in daily lessons. This is a pertinent issue as research has tied success in STEAM pedagogy with rich resources and instructional materials (Peters-Burton, Peters & Remold 2019). This may be improved if the administration and key authority figures in schools are trained and educated in the need, classroom reality and benefits of teaching Math and Science through STEAM education. The lack of understanding by administrators, along with teachers, has been cited as a challenge inimplementing and building cross-disciplinary connections in STEAM (Noh & Paik, 2014).

VI. RECOMMENDATIONS

Although studies establish that STEM or STEAM education can make learning meaningful and fun for the students, it is still not integrated with the curricula. This can be attributed to several reasons such as cost of materials, ease of use of materials, the time consumed in preparing a STEAM lesson,
no established curriculum, large classes and lack of funds, particularly in Pakistan's context. Thus effective professional development of teachers, well-defined STEAM lessons, availability of low cost, recycled material, relevant support through tutorials etc. can help teachers feel more confident to integrate STEAM concepts in their lessons. These ideas have been supported by other studies such as Kanadli (2019) and Siew, Amir, and Chong (2015). It is also suggested to incorporate STEAM lessons from early classes to reduce the hesitance and perception of teachers that it involves elaborate science and mathematical concepts.

REFERENCES

1. An, S. (2020). The impact of STEAM integration on preservice teachers' disposition and knowledge. *Journal of Research in Innovative Teaching & Learning, 13(1),* 27-42.
2. Anwar, T. (2017). *Design-based online teacher professional development to introduce integration of STEM in Pakistan*. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/185626.
3. Bae, J. H., Yun, B. H., & Kim, J. S. (2013). The effects of science lesson applying STEAM education on science learning motivation and science academic achievement of elementary school students. *Journal of Korean Elementary Science Education*, *32*(4), 557-566.
4. Baek, Y., Park, HJ, Kim, Y., Noh, S., Park, J., Lee, J., Jeong, J., Choi, Y., & Han, H. (2011). STEAM education in Korea. *Journal of Learner-Centered Curriculum and Instruction, 11(4),* 149-171.
5. Brown, J. (2012), "The current status of STEM education research", *Journal of STEM Education,Vol. 13 No. 5*, pp. 7-11.
6. Bybee, R. W. (2013). The next generation science standards and the life sciences. *The Science Teacher*, *80*(2), 25.
7. Bybee, R. W. (2014). NGSS and the next generation of science teachers. *Journal of science teacher education*, *25*(2), 211-221.
8. Bybee, R. W. (August 27, 2010). What Is STEM Education?. *Science New York Then Washington-, 329,* 5995, 996-999.
9. Carnevale, A. P., Smith, N., & Melton, M. (2011). STEM: Science Technology Engineering Mathematics. *Georgetown University Center on Education and the Workforce*.
10. Creswell, J. W. (2017). *Research design: Qualitative, quantitative and mixed methods*. Sage Publications.
11. DiFrancesca, D., Lee, C. and McIntyre, E. (2014), "Where is the 'E' in STEM for young children? Engineering design education in an elementary teacher preparation program", *Issues in Teacher Education, Vol. 23 No. 1,* pp. 49-64.
12. Erdogan, I., & Ciftci, A. (2017). Investigating the Views of Pre-Service Science Teachers on STEM Education Practices. *International Journal of Environmental and Science Education*, *12*(5), 1055-1065.
13. Guimarães, M. H., Pohl, C., Bina, O., & Varanda, M. (2019). Who is doing inter-and transdisciplinary research, and why? An empirical study of motivations, attitudes, skills, and behaviours. *Futures*, *112*, 102441.
14. Hali, A. U., Aslam, S., Zhang, B.H., Saleem, A. (2021). An Overview on STEM Education in Pakistan: Situation and Challenges. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 12*(1), 12A1T, 1-9. http://TUENGR.COM/V12/12A1T.pdf DOI:10.14456/ITJEMAST.2021.20
15. Hali, A. U., Zhang, B., Al-Qadri, A. H., & Bakar, M. A. (2020). An Overview Of Science Teacher Education In Pakistan. *Journal of Organizational Behavior Research*, *5*(1), 67-74.
16. 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.
17. Hole, Y., & Snehal, P. & Bhaskar, M. (2019). Porter's five forces model: gives you a competitive advantage. Journal of Advanced Research in Dynamical and Control System, 11 (4), 1436-1448.
18. Hong, O. (2017). STEAM education in Korea: current policies and future directions. *Science and Technology Trends Policy Trajectories and Initiatives in STEM Education*, *8*(2), 92-102.
19. Householder, D. L., & Hailey, C. E. (2012). Incorporating engineering design challenges into STEM courses. *Publication*s. Paper 166. https://digitalcommons.usu.edu/ncete_publications/166
20. Iqbal, H. M., & Mahmood, N. (2000). Science teacher education in Pakistan. In *Science Teacher Education* (pp. 75-92). Springer, Dordrecht.
21. Kanadli, S. (2019). A Meta-Summary of Qualitative Findings about STEM Education. *International Journal of Instruction*, *12*(1), 959-976.
22. Kang, N. H. (2019). A review of the effect of integrated STEM or STEAM (science, technology, engineering, arts, and mathematics) education in South Korea. *Asia-Pacific Science Education*, *5*(1), 1-22.
23. Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM education*, *3*(1), 1-11.
24. Lee, J. W., Park, H. J., & Kim, J. B. (2013). Primary teachers' perception analysis on development and application of STEAM education program. *Journal of Korea Society of Elementary Science Education, 32(1),* 47-59.
25. Lim, C. H., & Oh, B. J. (2015). Elementary pre-service teachers and in-service teachers' perceptions and demands on STEAM education. *Journal of Korean Society of Earth Science Education, 8(1*), 1-11.

26. Madden, M. E., Baxter, M., Beauchamp, H., Bouchard, K., Habermas, D., Huff, M., ... & Plague, G. (2013). Rethinking STEM education: An interdisciplinary STEAM curriculum. *Procedia Computer Science*, *20*, 541-546.
27. Malik, N. A. (2017). Challenges to High School STEM Education in Pakistan. *Systems Research and Behavioral Science*, *34*(3), 307-309.
28. Marmon, M. (2019). The Emergence of the Creativity in STEM: Fostering an Alternative Approach for Science, Technology, Engineering, and Mathematics Instruction Through the Use of the Arts. In *STEAM Education* (pp. 101-115). Springer, Cham.
29. Miles, M. B., Huberman, A. M., Saldaña, J. (2020). *Qualitative data analysis: a methods sourcebook*. SAGE.
30. Noh, H. J., & Paik, S. H. (2014). STEAM experienced teachers' perception of STEAM in secondary education. *Journal of Learner-Centered Curriculum and Instruction, 14(10*), 375-402.
31. Park, H., Byun, S. Y., Sim, J., Han, H. S., & Baek, Y. S. (2016). Teachers' perceptions and practices of STEAM education in South Korea. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(7), 1739-1753.
32. Peters-Burton, E. E., House, A., Peters, V., & Remold, J. (2019). Understanding STEM-focused elementary schools: Case study of Walter Bracken STEAM Academy. *School Science and Mathematics*, *119*(8), 446-456.
33. 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.
34. Scott, C. (2012), "An investigation of Science, Technology, Engineering and Mathematics (STEM) focused high schools in the US", *Journal of STEM Education, Vol. 13 No. 5*, pp. 30-39.
35. Shin, J. H. (2013). Survey of primary & secondary school teachers' recognition about STEAM convergence education. *Korean Journal of the Learning Sciences, 7(2),* 29-53.
36. Shin, Y., & Han, S. (2011). A study of the elementary school teachers` perception in STEAM (Science, Technology, Engineering, Arts, Mathematics) education. *Journal of Korea Society of Elementary Science Education, 30(4),* 514-523.
37. 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.
38. STEM Learning (2018). About us. https://www.stem.org.uk/. Accessed 29 Sep 2018.
39. Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research (J-PEER)*, *2*(1), 4.
40. Vockley, M. (2007). Maximizing the Impact: The Pivotal Role of Technology in a 21st Century Education System. *Partnership for 21st Century Skills*.
41. Wagner, T. (2008). Rigor redefined. *Educational leadership*, *66*(2), 20-24.
42. Wu, Z. and An, S. (2015), *Teaching Elementary and Middle School Mathematics Using the MSA Approach: Model, Strategy, and Application*, 2nd ed., Education for All Publisher, Irvine, CA.