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Factors behind the implementation of STEM education in Bangladesh

Sabbir Ahmed Chowdhury¹, ASM Shamsul Arefin², Fariha Ahmed¹
¹Institute of Education and Research (IER), University of Dhaka, Dhaka – 1000, Bangladesh
²Department of Biomedical Physics and Technology, University of Dhaka, Dhaka – 1000, Bangladesh

E-mail: arefin.bmpt@du.ac.bd

Abstract. In this world of ever growing challenges; Science, Technology, Engineering, and Mathematics (STEM) has gained momentum in global education systems. Unfortunately, Bangladesh as a country is yet to be on board with this advanced education system. No research has been published related to STEM education in Bangladesh. Hence, the aim of this study was to explore the key factors and major challenges behind the implementation of STEM education system in Bangladesh. The design of the study followed mixed method approach. Undergraduate students of the University of Dhaka were selected as sample using non-random purposive sampling technique. Data were collected from the participants through semi-structured questionnaire and focus group discussion. According to the primary findings, more than 80% of the respondents agreed that infrastructure and resources as well as professional development are the key factors to implement STEM in Bangladesh. In addition, inadequate scientific laboratory facilities, lack of financial resources, lack of training for trainers and large class size have been identified as the major challenges behind the implementation of STEM. Keeping these factors and challenges in mind, an effective STEM based education system can be developed and successfully implemented in phase by phase from primary to tertiary levels. This study has, therefore, implications for policy makers, educationists and stakeholders in both private and public sectors to increase the country’s global competitiveness as well as boost the national economy via providing the STEM based skills and capacity to the learners.

1. Introduction

The success of any nation depends heavily on its education system. Hence, investing in education has been viewed globally as a vital step towards producing citizens who can participate in a meaningful manner to the development of a nation [1]. However, an educational system, based on the traditional learning techniques, i.e., reading, writing, and arithmetic skills, has been found wanting in the technological world of today and tomorrow [2]. Additionally, a workforce with static and rigid skill sets would face difficulty to compete in the global economy where discovery, innovation, and rapid adaptation are necessary elements for success [3]. In this context, the blended study of Science, Technology, Engineering, and Mathematics (STEM) for all learners in an educational system vows to provide a meaningful preparation for learners to become successful in the ever changing world [4]. STEM education is viewed as an interdisciplinary approach of learning that allows learners to combine scientific,
engineering, mathematical and technological concepts in dealing with various scenarios ranging from day to day activities to globally relevant issues [3]. STEM education provides the skill sets that include analytically recognizing a problem, assessing the problem based on STEM concepts and developing the methodology to solve the problem [5]. These skill sets provide the learners with a competitive edge in a wide range of disciplines that helps them to contribute in the various national developments in their respective countries that in turn promotes a country’s economy and global competitiveness [6].

Realizing the benefits and possibilities of STEM, advanced countries in the world, like the USA and the European Union (EU) have taken giant strides in integrating STEM education in their education systems since the last decade [2]. Likewise, countries like Australia, India and Malaysia have embraced the concepts of STEM and implemented STEM education system with relative success and challenges [7]. Furthermore, the trend of STEM education is taken on board in Asian countries like China, Korea, Singapore, Taiwan, etc. in various formats [8]. In the similar manner, many countries in the African continent have reformed their education systems in recent years. Absorbing the integral essence of STEM education, most of the African countries started with strengthening science education via a variety of approaches in a view to increase the economic growth and create greater employment opportunities [9].

To reap the positives of STEM education system, the key factors behind the implementation of STEM education need to be examined. Some researchers reported that proper funding and availability of relevant resources in elementary and secondary schools make students better engaged and successful in STEM education [10]. Additionally, high quality teacher recruitment plays a vital role in STEM education system which is eventually backed by healthy school resources [11,12]. On a different note, some researchers identified the influence of families on young adults in pursuing STEM education as a key factor. They opined that the congenial and supportive atmosphere in those families promoted the young members to pursue STEM based curricula [13,14].

Despite multifaceted benefits, some researchers have argued that the abstract nature of STEM concepts may act as a potential barrier to gain STEM understanding for all learners [15]. Similarly, it has been reported that learners, completing their secondary education with science and mathematics based subjects, hesitate to pursue STEM based curricula [16]. Besides, there remains a gender disparity in STEM education system. It has been reported that the participation, completion and performance of STEM courses are dominated by males with respect to females [17,18,19].

In this context, integration of STEM in a country’s education system is a logical consequence. Unfortunately, a country like Bangladesh that is aspiring to become one of the developed countries in the world is way behind in realizing, let alone adopting STEM education system. No research regarding STEM education in Bangladesh is yet to be reported. Hence, the aim of this research article was to explore the key factors and challenges behind the implementation of STEM education system in Bangladesh. Enumerating the rationale and purpose statement initially, the article presents the methodology of the research. Eventually the article comes to its conclusion after discussing the key findings.
2. Rationale and Purpose Statement

The motivation behind the implementation of STEM education is to prepare the 21st century workforce by heightening a learner’s ability across a wide range of disciplines. Additionally, the focus of STEM education is to enhance the bunch of learners who are prepared to enter secondary onwards education and pursue careers in STEM related fields [3]. Realizing the benefits and possibilities of STEM, advanced countries in the world have already moved forward in integrating STEM in their education systems. Unfortunately, Bangladesh, one of the developing countries in the world, is still far behind in embracing the STEM education system to promote economic and technological progress. Hence, there lies a timely need to explore the key aspects and threats behind the integration of STEM in education system of Bangladesh. Accordingly, this study sought to respond to the succeeding research questions:

(i) What are the key factors behind the implementation of STEM education in Bangladesh?
(ii) What are the primary challenges in implementing STEM education in Bangladesh?

3. Methodology

This study used a mixed method approach. Non-random purposive sampling technique was used to define sample. The population was comprised of public universities, in which University of Dhaka was selected as a sample. 100 graduate level students of this university were treated as sample participants. Data were collected through semi-structured questionnaires and Focus Group Discussions (FGD). 5 point Likert scale was used in the questionnaire to categorize the primary factors. Participants, who agreed or strongly agreed about the factors, were asked to mention the sub-domains of primary factors. Subsequently, sub-domains of each factor were listed based on open-ended responses of the participants. Finally, 2 FGDs, each comprised of 6 students, were conducted to investigate the major challenges in implementing STEM education. Participants were informed about the purpose of the study before involving them as samples. Total confidentiality and anonymity were ensured in presenting data in data analysis section.

4. Results and Discussions

Factors behind implementing STEM and major obstacles to do so were identified through questionnaires and FGDs of participating students. The findings are described in the following subsections in accordance with the research questions.

4.1. Factors behind implementing STEM

Responses of the participants about the primary factors behind the implementation of STEM education is listed in Table 1. It can be observed from Table 1 that infrastructure and resources are the most dominant factors to implement STEM. Besides, most of the participants agreed that professional development and learner engagement also influence in implementing STEM. Furthermore, they also
considered learners’ attitude and family involvement as key players behind the implementation of STEM education.

Table 1. Primary factors behind implementing STEM

<table>
<thead>
<tr>
<th>Primary factors</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure and resources</td>
<td>37.5%</td>
<td>52.0%</td>
<td>7.5%</td>
<td>3.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Professional development</td>
<td>37.7%</td>
<td>42.3%</td>
<td>13.0%</td>
<td>4.7%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Learner engagement</td>
<td>32.3%</td>
<td>44.5%</td>
<td>18.3%</td>
<td>2.8%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Learners’ attitude</td>
<td>30.4%</td>
<td>38.6%</td>
<td>21.1%</td>
<td>7.3%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Family involvement</td>
<td>26.5%</td>
<td>43.0%</td>
<td>17.0%</td>
<td>10.0%</td>
<td>3.5%</td>
</tr>
</tbody>
</table>

The responses obtained in Table 1 were further investigated using parametric independent t-tests to find out whether there were any significant differences in opinions on primary factors between male and female. The t-test results are provided in Table 2.

Table 2. Independent t-table for primary factors based on gender

<table>
<thead>
<tr>
<th>Primary Factors</th>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>P- value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure and resources</td>
<td>male</td>
<td>59</td>
<td>4.2203</td>
<td>.73268</td>
<td>0.855**</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>41</td>
<td>4.1951</td>
<td>.59032</td>
<td></td>
</tr>
<tr>
<td>Professional development</td>
<td>male</td>
<td>59</td>
<td>4.1921</td>
<td>.62882</td>
<td>0.034*</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>41</td>
<td>3.8699</td>
<td>.87203</td>
<td></td>
</tr>
<tr>
<td>Learner engagement</td>
<td>male</td>
<td>59</td>
<td>4.0339</td>
<td>.53429</td>
<td>0.625**</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>41</td>
<td>3.9817</td>
<td>.50741</td>
<td></td>
</tr>
<tr>
<td>Learners’ attitude</td>
<td>male</td>
<td>59</td>
<td>3.8686</td>
<td>.67969</td>
<td>0.390**</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>41</td>
<td>3.7541</td>
<td>.61037</td>
<td></td>
</tr>
<tr>
<td>Family involvement</td>
<td>male</td>
<td>59</td>
<td>3.7542</td>
<td>.91148</td>
<td>0.675**</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>41</td>
<td>3.6829</td>
<td>.70495</td>
<td></td>
</tr>
</tbody>
</table>

* indicates significant difference and
** indicates non-significant difference at 0.05 level of significance

According to Table 2, there was a significant difference in mean for professional development score between male and female (p < .05). The average of professional development selection score for male (M=4.1921, SD=0.62882) was greater than the average professional development selection score for female (M=3.8699, SD=0.87203) by a margin of 0.322. However, we can accept the null hypothesis for the average scores of the other primary factors (Infrastructure and resources, Learner engagement, Learners’ attitude, Family involvement) and conclude that the mean scores for those primary factors had no significant differences for male and female.

Subsequently, participants, who agreed or strongly agreed about the factors listed in Table 1, were asked to opine about the sub-domains of primary factors. They provided a number of sub-factors that can
be itemized under the primary factors as provided in Table 3.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Infrastructure and resources</th>
<th>Professional development</th>
<th>Learner engagement</th>
<th>Learners’ attitude</th>
<th>Family involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-domains</td>
<td>Laboratories</td>
<td>Training</td>
<td>Collaborative learning</td>
<td>Better career options</td>
<td>Learning equipment provided by family</td>
</tr>
<tr>
<td></td>
<td>Relevant Text Books</td>
<td>Workshop/conference</td>
<td>Assignment based on activities</td>
<td>Prestigious field</td>
<td>Consultation with teachers</td>
</tr>
<tr>
<td></td>
<td>Technology resources</td>
<td>Experience</td>
<td>Group/individual Presentations</td>
<td>Remove gender disparity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Non-threatening atmosphere</td>
<td>STEM subjects are difficult</td>
<td></td>
</tr>
</tbody>
</table>

The sub-domains listed in Table 3 correspond to the findings reported in STEM literature. The need of technology resources like computers, audio-visual aids, etc. conforms the findings of Wang et al. who reported about the difficulty to embed technology elements into the STEM classes without proper technology resources [20]. Additionally, the availability of relevant and quality STEM textbooks plays vital roles in implementing STEM education. This viewpoint epitomizes the works of multiple researchers who reported similarly that quality textbooks would enhance the possibilities of successful implementation of the STEM education system [12,20,21]. Furthermore, the experience of teachers plays a key role in the success of STEM education. Some researchers echoed in the similar manner that teachers’ prior experience facilitates the success of STEM education [22,23]. Moreover, multiple studies have reported that learners are better motivated and more engaged in learning if the learning activities are practical or application-based [21,24].

4.2. Major Challenges of implementing STEM

It is vital to understand and reduce/avoid implementation risks to adopt STEM initiatives. Hence, in FGDs participants were asked to identify major challenges to implement STEM education. Participants identified some vital challenges in implementing STEM education as following:

i. Lack of well-equipped scientific laboratory

The results of the current study revealed that the almost all of the participants agreed that standard scientific laboratories are the most dominant factors to facilitate the implementation of STEM. This finding was commensurate with the observations of multiple researchers who reported that STEM implementation is visibly hampered due to the scarcity of basic laboratory equipment [25,26].

ii. Lack of financial resources to purchase materials
The FGD participants expressed that schools without the necessary teaching resources and supplies can be under tremendous pressure to implement STEM education effectively. This viewpoint is well reported in the works of Margot and Kettler, where public schools receiving lower public budgets are facing difficulty in implementing and ensuring the quality of STEM education [6].

iii. Lack of training

In FGD, most of the students opined that teachers’ lack of training may create obstacle shifting towards STEM education. This observation confers to the works of multiple researchers who reported that teachers participating in professional STEM development programs tend to show better confidence, mastery and skills in teaching STEM courses [21, 27].

iv. Large class sizes

The FGD participants also conveyed that large class sizes may impact negatively in the implementation of STEM education in schools. Similar findings were reported in the work of Ugo and Akpoghol [25].

v. Negative attitude towards STEM subject

In FGD, most of the students opined that STEM subjects might become more challenging at secondary school level which is in line with the observations of Xie et al. [13]. Furthermore, FGD participants had their doubts on the traditional unsupportive learning environment that may not be favorable enough to cater to the enthusiasms of the learners to participate in STEM subjects.

vi. Limited parental involvement

According to our study, learners did not want to take up STEM subjects because of the attitude inherited in families and society, which was in line with the previous study of Mabhanda [16].

The challenges identified above through FGDs endorse the findings mentioned by the California Department of Education. They reported that several key aspects like availability of quality STEM instruction materials, hands-on engagement of learners, the professionalism of teachers, etc. need to ensure for the successful integration and ensuring the benefits of STEM education [28].

5. Conclusions

The study examined how STEM education can be implemented in Bangladesh by focusing on the dominant factors as well as overcoming the challenges. The study reports that standard laboratories, trained teachers and relevant text books are the pre-requisite to facilitate the implementation of STEM education. Additionally, the study argues that non-threatening collaborative learning atmosphere and family support can positively promote STEM implementation. However, there was a difference of opinions between male and female respondents about the professional development in STEM education. On the other hand, the challenges of STEM implementation encompassed on the lack of well-equipped science laboratories, lack of financial resources to purchase learning materials especially chemicals, large class sizes, negative attitude towards STEM subjects by some learners, and limited parental involvement in their children’s learning. Hence, the study recommends that the Ministry of Education under the Govt.
of Bangladesh and the other stakeholders should expedite the development of resourceful scientific laboratories and provision of material and financial resources to initiate integration of STEM in the education system. Finally, the study suggests that further research works may be performed with larger samples from both urban and rural schools to get deeper insight to develop a national framework of STEM education as a way forward.

References


