Understanding Science Teachers’ Implementations of Integrated STEM

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Science teachers generally have a positive attitude towards using STEM-based activities. In addition, data revealed that participants implement integrated STEM into their teaching frequently and regularly. Results also indicated teachers encounter challenges while implementing STEM: documentation, the vast curriculum content, and lack of time. Moreover, external challenges (i.e., the lack of supportive guidelines) rather than teachers’ competency (i.e., having sufficient knowledge and skills for implementing STEM teaching) appeared to have the highest impending impact.

Keywords: science ; science teacher ; STEM education ; attitudes

1. Introduction

Science, Technology, Engineering, and Mathematics (STEM) education focuses on the production of STEM-literate graduates with the necessary skills for excelling in the technologically oriented future workforce [1]. Although STEM has received global attention and calls; research on science educators has revealed several concerns about the science education current situation, such as that (1) many students find little of interest or even dislike science; (2) science is taught as the transmission of facts of little relevance, and is too complex; (3) school experience leads to loss of interest in science and technology as career possibilities [2]. Moreover, the international assessment results revealed how students in UAE scored below the average score in science assessment of both Trends in International Mathematics and Science Study (TIMSS) and Programmed for International Student Assessment (PISA) [3].

Those findings can be related to the concerns raised earlier in the research on science educators and how science is being taught and learned. In contrast, Herro et al. [4] argued that the purpose of science programs in schools is to develop scientifically literate citizens. In particular, science, mathematics, and technology are interdependent human enterprises with strengths and limitations. To be scientifically literate means to understands critical concepts and principles of science, be familiar with the natural world and recognize both its diversity and unity, and to be able to use scientific knowledge and scientific ways of thinking for individual and social purposes [5]. However, Johnson [6] reported that the integration of STEM implementation faces several challenges: (1) STEM integration requires restructuring of interdisciplinary curriculum and lessons; (2) integrated STEM education often requires numerous materials and resources for students, such as construction tools; (3) creating a school culture and environment that supports an integrated STEM approach to teaching and learning can be costly and time-consuming; (4) effective STEM education relies on qualified teachers who can teach and implement the interdisciplinary approach [5].

Today, STEM integration is a widespread teaching approach. It has an essential role in providing students with a vital education in science and other subjects [2][3][6]. For this purpose, the UAE education system is moving toward STEM education in its education reforms plans, aiming to develop an innovative education system for knowledge and a globally competitive society by coping with the global market demands [7]. Various innovation conferences and festivals have been held to highlight the finest approaches in attaining the STEM integration objective [8].

2. STEM Definition

Science, technology, engineering, and mathematics or STEM abbreviation was introduced at National Science Foundation (NSF) in 2001 [9], by the assistant director of the Education and Human Resources Directorate [10]. At that time, she described STEM as an educational inquiry process where the learning process was modeled by students solving a real-world problem. In contrast, Joyner [11] defined STEM as a meta-discipline integrating the four disciplines.

Another definition considered STEM integration as a widespread teaching approach. It has an essential role in providing students with a vital education in science and other subjects [12]. Jolly [13] looked at STEM from a different angle as innovation pursuits. Alternatively, Johnson [6] reported that STEM integration refers to students participating in the engineering design process to develop technologies that require meaningful learning through integration and application of mathematics and science. On the other hand, refs. [14][15] asserted no consensus regarding the definition of STEM in terms of nature, degree of integration, and connections between the different STEM disciplines. At the same time, other researchers [4][10][16][17] focused on the importance of applying equal attention to two or more STEM disciplines and explicitly assimilating concepts from various STEM disciplines.

3. Nature of STEM Integration

There were several views regarding integrating STEM education in science education in the previous studies. Some focused on bringing together all STEM disciplines through explicit content area connections or interdisciplinary content, providing more relevant, less fragmented, and more stimulating experiences for learners [18][19][20][21]. Other researchers emphasized that STEM integration must shift toward student-centered teaching that relies on authentic, real-world problems that promote active learning [22][23].

Many studies focused mainly on incorporating specific instructional strategies for integrating STEM with inquiry-based learning, problem-based learning, or design-based learning [24][25][26][27]. On the other hand, the opponents of the integration process have rebelling vision related to adopting such an approach that requires the restructuring of many elements, ranging from the training of STEM teachers to changing the structure of education programs from the revision of measurement-evaluation methods. In particular, the time cost of making such significant changes stands as a barrier in front of this reform [28].

Moreover, education researchers indicate that teachers struggle to connect the STEM disciplines [29].

4. Interest and Career

Several research studies discussed that STEM integration impacts students' interest and engagement in science learning and toward STEM careers [30][31][32][33]. Xie et al. [34] cite that STEM education focuses on the production of STEM-literate graduates with the necessary skills for excelling in the technologically oriented future workforce. Kant et al. [35] believed that integrated STEM education could be a platform for developing essential personal and professional competencies, including research inquiry, problem-solving, critical and creative thinking, entrepreneurship, collaboration, teamwork, and communication. Herro and Quigley [36], in their study, found that STEM programs in the USA have three primary and inclusive goals for STEM education: (a) increase the number of STEM innovators and professionals, (b) strengthen the STEM-related workforce, and (c) improve STEM literacy in all citizens. Dori et al. [37] presented a contradictory argument about a STEM workforce shortage in the United States. He argued that science and engineering workers had increased at a steady rate of 2.7%, sufficient to increase job growth. However, he postulated concern centered on the United States' decreasing global dominance in science and engineering, national security, research, and development logjams in research universities, and changing demographics.

On the other hand, references [38][39][40] reported that learning science and mathematics through an integrated engineering design process enhances knowledge and critical thinking skills and promotes interest in science and engineering careers. Moreover, other studies assert that integrated STEM education leads to increased interest in STEM field careers and is essential for student success as they progress into the future [38]. STEM courses and programs can increase students' competencies for STEM-related occupations and understanding of scientific and engineering work [41]. Improved STEM education may necessitate a change in the structure of higher-education institutions by restructuring curricula to produce graduates who are versatile, adaptable, and highly employable, specifically, graduates in engineering, health sciences, computer sciences, and natural sciences [42].

5. Challenges of STEM Integration

Haesen and Van de Put [43], in his study, reported teachers' barriers that prevent the successful implementation of STEM integration in a science classroom: (1) classes become crowded and are hardly managed; (2) science content is too significant to adopt the STEM approach as it is time-costly, and (3) teachers lack the needed knowledge to teach using the STEM approach. On the same track was [11], who discussed several challenges that highly hinder the implementation process: (1) STEM integration requires restructuring of interdisciplinary curriculum and lessons; (2) integrated STEM education often requires numerous materials and resources for students, such as construction tools; (3) creating a school culture and environment that supports an integrated STEM approach to teaching and learning can be costly and time-consuming; (4) effective STEM education relies on qualified teachers who can teach and implement the interdisciplinary approach.

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