# Science Teachers' Perceptions of STEM Education: Possibilities and Challenges

H. El-Deghaidy
Graduate School of Education, American University in Cairo, Cairo, Egypt
Curricula and Instruction, Suez Canal University, Ismailia, Egypt
The Excellence Research Centre of Science and Mathematics Education, King Saud University, Riyadh, Saudi Arabia
Email: h.eldeghaidy@aucegypt.edu

N. Mansour
University of Exeter, Exeter, UK
The Excellence Research Centre of Science and Mathematics Education, King Saud University, Riyadh, Saudi Arabia
Email: N.Mansour@exeter.ac.uk

***Abstract*—In order to promote STEM (Science, Technology, Engineering, and Mathematics) education through developing a professional development model, this study seeks to identify science teachers' perceptions regarding STEM education and its interdisciplinary nature, and to identify the factors that facilitate and hinder such a form of instruction in their schools. Being one of the first studies of STEM education in Saudi Arabia, this study elicits science teachers' perceptions through the use of qualitative methodologies. The instruments include focus groups, teacher-reflection and an interview protocol. The study ends with recommendations that could lead to develop a professional development model of what science teachers need in terms of pedagogical content knowledge to enact STEM education in class.**

***Index Terms*—STEM education, science education, interdisciplinary, science teacher induction.**

## I. Introduction

The integration of Science, Technology, Engineering and Mathematics, known as STEM education, is a growing area in developed and developing countries [1], [2]. There is a widespread depiction of STEM education but there are various interpretations of what it actually entails. STEM education, in the focus of this study, aims to shift teaching practices from traditional lecture-based teaching into those that are inquiry, project-based and problem-based learning as a means to present interdisciplinary, meaningful learning experiences that could include two or more of the four main disciplines identified in STEM education. Within such interdisciplinary philosophy, deep conceptual understanding and what is termed as 21st century skills could be developed [3].

Yet, research findings indicate that science and math teachers lack pedagogical knowledge and efficacy when it comes to STEM education [4], [5]. This has put demands and challenges on professional development (PD) providers to design programs that address teachers' needs and introduces new concepts [6].

### A. Context of STEM Education in Saudi Arabia

Science and Mathematics in Saudi Arabia are taught from the first through tenth grade as compulsory subjects for all students (primary through middle school) in gender segregated schools in compliance with cultural principles [7]. In both the eleventh and twelfth grades (secondary stage), students are taught science and math only if they choose the scientific track. As in most countries, in the primary and middle schools, science is introduced as one subject where science classes and textbooks include biology, chemistry and physics content, while it starts in the tenth grade to branch out to specific subjects - biology, chemistry, physics and geology [8].

As for teacher education, teacher education programs are discipline-oriented, each in their silos. Science and math teachers are usually prepared through several teacher-education institutions.

When it comes to implementation and teacher practices in schools after finalising educational programs, it is noticed that classroom teaching is mostly done independently as teachers prepare and deliver their lessons individually. This in itself sets the tone for a certain culture in the school of how teachers work and how they interact together within and across disciplines. It is not common, therefore, that science and math teachers, for example, sit together and identify cross-cutting content or skills. Accordingly, the three possible models of instruction of an interdisciplinary curriculum (parallel, cross-disciplinary and infusion) do not exist in current practices [9]. As for the practical side of science teaching, most schools, in general, are equipped with science labs where students can carry out hands-on activities. There is, however, no precise organisation or pre-set requirement plans to students' visits to the labs. Having said that, it is commonly perceived that labs are not utilized as expected or required by the curriculum.

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### B. The Research Problem and Questions

It is common practice throughout many Arab nations that subjects such as science and mathematics are taught separately as 'silos' through a discipline-based approach with limited connection to real life situations. For teachers to shift from their comfort zones of teaching in the 'silos' and promote for an 'integrated' STEM education learning model, there is a need to identify how teachers perceive such integration and implementation in addition to identifying the factors, from their point of view, which could facilitate or hinder the enactment of such integrated practices.

Nonetheless, for teachers to introduce STEM education into their schools several aspects should be taken into consideration. These include teachers' deep content knowledge, strong belief in innovative teaching strategies that has at its core student centred teaching, interdisciplinary learning to building bridges across subjects, and the development of strong teams that are able to create a culture of success in schools through professional communities. There are claims that the number of mathematics and science teachers with hands-on experience working in STEM education is limited and teachers may also lack educational background in STEM according to a finding by NSF that 30% of science middle school teachers lack in-field training [NSF 2012, cited in 10].

In order to promote STEM education, this study seeks to identify teachers' perceptions regarding STEM education and its interdisciplinary nature, identifying the factors that facilitate or hinder such a form of instruction in their schools. Being one of the first studies on STEM education in Saudi Arabia, the research questions focus on the following:

- What are science teachers' perceptions of STEM education?
- What are the factors that facilitate and hinder STEM education practices?

## II. Research Methods

The authors opted to administer a qualitative instrument. The instrument was used consecutively to strengthen the quality of evidence that would help identify how teachers perceive STEM education and code their perceptions using a grounded theory approach to data analysis. The study used focus group interviews to discuss science teachers' familiarity with and perceptions of STEM education and interdisciplinary activities conducted in their schools. The 21 participating teachers involved in the focus groups represented 21 different middle schools in Riyadh from a total of 418 schools. Teachers were randomly grouped on their arrival at the local district office, where the focus group took place, into five groups.

### A. Participants

Participants of this study included middle school Saudi science teachers in local educational districts in Riyadh. These districts were chosen because they are part of the partnership program with the centre which is sponsoring this study. All teachers involved were science middle school male teachers who agreed to participate on a voluntarily basis and signed a consent form that was approved by Institutional Review Board. A total of 23 teachers were involved in the study. We anticipated requiring teachers to administer three key instruments developed by the authors. These were lesson plan protocol, reflective paper, and a semi-structured interview protocol. Only two teachers were able to agree to work with the authors and commit to participating due to the limited time they could afford to spend on the study yet others teachers' interest in such an innovative topic was noted.

### B. Data Analysis

Responses from teachers' focus group interviews were analysed through identifying themes and by using the constant comparison method. Both processes of data collection occurred simultaneously throughout the period of the study. After completing the data collection, we coded participants' responses and transcribed and analysed them in four major stages:

- Inductive coding, which corresponds to open coding in grounded theory;
- Conceptual refinement, where critical reflection on empirical statements were conducted;
- Building categorical structures which involve combining categories into theoretical statements corresponding to axial coding in grounded theory), and
- Theory condensation, which means selective coding.

### C. Findings and Discussions

Teachers' views of STEM interdisciplinary teaching and learning: The findings of the study showed that all the teachers expressed concerns that they are underprepared to use STEM applications with their students in the classroom. Lack of teachers' preparation to implement STEM practices may explain their views of interdisciplinary teaching and learning across STEM subjects. The majority of the teachers who participated in the study believed that technology as hardware (e.g. computer, laptop, camera, ipad, etc.) is a core element for the integration of STEM in the classroom. This showed that teachers did not have sufficient understanding of the T in STEM. It also showed that science teachers may not have an adequate understanding of the nature of science and technology and the interactions between these two disciplines, when and if integrated.

Teachers' views of STEM Integration: Teachers acknowledged that STEM education can help in promoting 21st century skills including thinking skills, collaboration, problem solving, and research skills that could all be useful for selecting careers in science. Teachers in this study identified that teaching STEM and linking the school science to real life situations are necessary to inspire students to take future careers in STEM. The local culture of the students including peers, family, industries, career models, and the use of technology in everyday life can induce students' interests

 

in studying science and understanding STEM and take careers in STEM. Therefore, it is important to take advantage of the local culture and raise awareness of the applications of STEM through science lessons.

STEM partnership-based Professional Development programs: Teachers in this study suggested that a direct dialogue between science teachers, math teachers, scientists, and engineers about STEM applications and activities would be essential for promoting STEM education in schools. They suggested that this dialogue can happen through a partnership between STEM parties. In addition, teachers in this study suggested that these partnerships can replace the traditional professional development programs and that teachers and engineers can work together to design models to explain scientific concepts. This experience provides insight into the ways teachers and scientists can assist students' making meaning during scientific investigations [11].

STEM as part of the school culture: One of the important findings of this study showed that the school culture plays a key role concerning the implementation of STEM at school. The study showed that STEM integration required a different school culture than that in non-STEM schools. The STEM school culture required collaboration among stakeholders and building a collaborative and supportive STEM community in school. In this STEM school culture exchange of experience and constant dialogue between teachers and the administrators in the school were highly emphasized. In this sense, Stoll and Fink (1996) list collegiality as one of teeatures of a positive school culture, which includes shared goals and responsibility for success, continuous improvement, lifelong learning, risk-taking, support, mutual respect, openness and humour. Our anticipation of the depicted main aspects discussed above for a STEM school based professional development model is illustrated in Fig. 1.

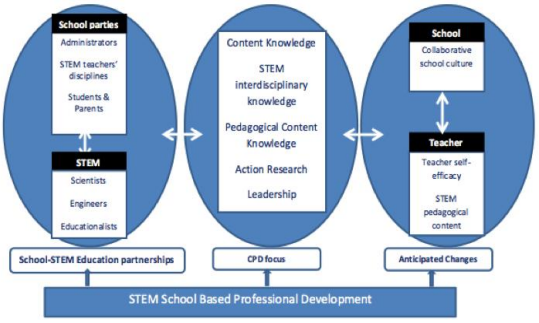


Figure 1. STEM school based professional development model

## III. Conclusions

This study fills a gap in the research field of STEM education in the Arab region in general and in Saudi Arabia in particular, as it seeks to understand the current perceptions that teachers hold towards STEM education and its core interdisciplinary nature. The study findings are to bring a non-Western perspective of science teachers in the context of STEM education. The study therefore can provide recommendations at the policy level to introduce programs for pre-service and in-service teachers. This could lead to developing a STEM partnership-based Professional Development model of what teachers need in terms of content knowledge and pedagogical content knowledge to enact STEM education in class.

## IV. Future Research

Our study focused on one group's views (teachers) who are dealing with STEM education. However, teachers' reflection on the issues that can facilitate or hinder STEM integration in the science lessons have established a critical need for exploring students' interest and views of STEM careers as well as students' attitudes toward STEM. It would also be very useful to conduct a study to look at student learning when implementing a STEM integration lesson in a science classroom and collect data about students' views of STEM integration and the pedagogies their teachers use to help them understand science through STEM education. It would also be necessary to plan school-STEM-based professional development (S-STEM-BPD) programs and study the science teachers' views of these professional programs, and explore science teachers' perspectives of the contextual issues that have an impact on putting the learning emerging from the S-STEM-BPD programs into practice. Teachers made comments about the lack of STEM activities in the science curriculum, so it would be important to carry out content analysis of the science curricula across different educational stages to explore the potential of these science curricula to promote STEM education. Teachers reported concerns about their knowledge of the STEM disciplines, so it is essential for developing effective STEM teacher professional development to identify teachers' professional needs to teach STEM effectively.

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**H. EL-Deghaidy** Born in Egypt 1968, is an associate professor of curricula and science instruction at the Graduate School of Education (GSE), American University in Cairo, Egypt. At GSE, she is the Director of the STEAM education Centre. Dr. EL-Deghaidy graduated from the University of Birmingham UK in science education in 2001. Her PhD looed at investigating learning science concepts in Egypt through a constructivist lens. She previously served as assistant professor at Suez Canal University (SUC). In her capacity in curricula development and instruction, she served as a coordinator of two TEMPUS projects funded by the European commission. She supervised many theses at the Master and Doctorate levels. Her main research interests are Constructivism, e-Learning, STEM/STEAM education and Education for Sustainable Development. Throughout her career, El-Deghaidy published many research papers in international journals and conferences.

Dr. EL-Deghaidy's professional service is reviewing manuscripts and proposals for international journals with high impact factors, in addition to serving as Strand coordinator for the National Association for Research in Science Teaching (NARST) 2012-2014. Dr. EL-Deghaidy is a member of international organizations including ESERA and NARST in addition to national Arab and Egyptian Organizations such as ESSE, ECCI and AETS.

**Nasser Mansour** Born in Egypt 1971, is a senior lecturer in science education at the Graduate School of Education at Exeter University. He is Fellow of the Higher Education Academy (HEA). At Exeter University, he is the Director of the Centre for Science, Maths and Technology Education and the Programme Director for the MSc in Educational Research. Dr. Mansour graduated from University of Exeter, UK in 2008. His PhD looked at teachers' beliefs and practices about STS with emphasis on the interaction between cultural issues e.g. religious beliefs and the teaching of Science.

He published in prestigious education journals such as Science Education, International Journal of Science Education, Journal of Science Teacher Education, Cultural Studies of Science Education, Research in Science Education, Computer and Education and European Educational Research. His recent book is "Science Education for Diversity: Theory and Practice (Springer, 2013)". Dr. Mansour has been awarded the best paper Award at the European Educational Research Association conference in 2007 and The University of Exeter Merit Award in 2011. Dr. Mansour has been involved in international educational projects in Egypt, Saudi Arabia and UK.

Dr. Mansour is a member of national organizations including ESERA, NARST, ASTE, BAAS and BERA and is currently associate editor of the journal Thinking Skills and Creativity and was President of the Junior Researcher JURE 2011 Pre-conference of EARLI European Association of Research on Learning and Instruction (EARLI) Conference held at Exeter.

 