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EDITORIAL

STEM Education: "What's in a Name?"

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Abstract

In this editorial, I am explaining my background in STEM education course design, delivery, and research experiences and discussing the current state of STEM journals internationally. I am also including a short overview of the three articles of this inaugural issue of Hellenic Journal of STEM Education.

Keywords: Origins of STEM Education, STEM education journals, STEM education publications

Juliet: *"What's in a name?*
That which we call a rose by any other name would smell as sweet."
Romeo and Juliet (II, ii, 1-2)

An Effort of Design and Implementation for an Integrated STEM Course

While I was a doctoral student at Penn State in late 1990's, an outreach project of the College of Engineering was launched in collaboration with the College of Education. The two colleges "In response to the many calls for reform and innovative response by a series of important landmark commissions in science education developed a new, introductory course for teachers entitled: "Fundamentals of Science, Technology and Engineering Design"" as we wrote in the white paper. I was a team member for course development and one of the instructors. The team had professors and graduate assistants from the colleges of engineering and education. That experience gave me tremendous opportunities for learning the basics of engineering design and pedagogies related to, what we call today, "integrated STEM education." The target group was elementary education majors at PSU College of Education. With a little background in science learning and almost no positive science learning experiences our prospective classroom teachers took this course to fulfill their science elective requirements. The course format was appealing to our students. With hands on approaches and little lecturing, they hardly got bored. The course also had features of flipped classrooms. Students were required to work in small groups of 'engineering teams' and try to solve a 'simulated real-life' engineering design problem during the entire semester by also creating computer simulations and 3D models (see **Figure 1**) in the process. Throughout the semester, they created artifacts (see **Figure 2**) by which they could show their developing understandings of the underlying physics concepts (e.g. force, compression, and tension). A competition among the groups (engineering teams) propelled their enthusiasm. The end products were something they could proudly display and explain to others what they have learned (see **Figure 3**). We documented our STEM course development efforts and its efficiency in several publications almost 20 years ago (i.e. Tasar, Taylor, & Dana, 1999; Taylor, Dana, & Tasar, 2001; Taylor, Lunetta, Dana, & Tasar, 2002).

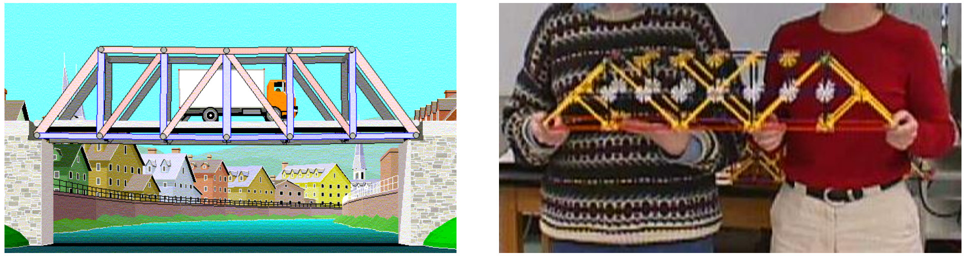

Figure 1. A simulation of the working of a student team's bridge design and a 3D model created by K'NEX pieces (1998).

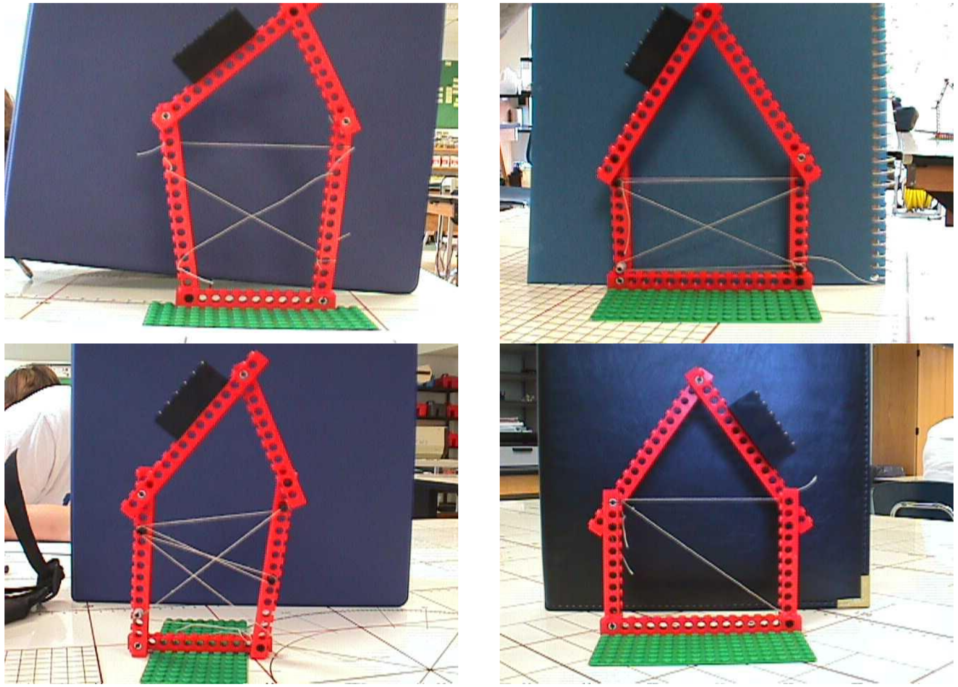

Figure 2. Students experimenting to understand how beams and strings behave under compression or tension and how they could be used to create sound structures (1998).

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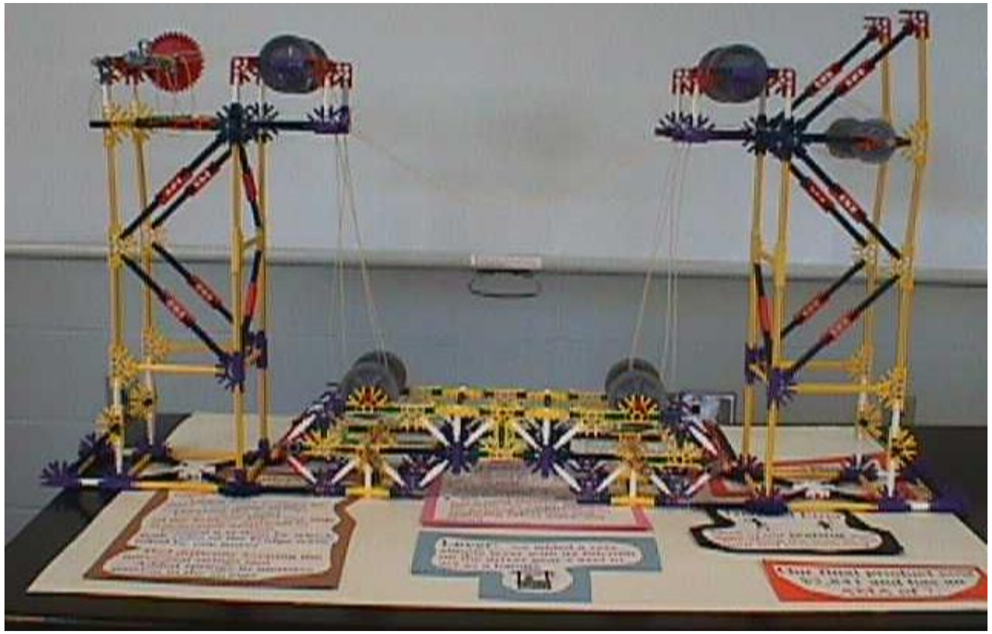

Figure 3. A lift bridge design display created by elementary education majors (1998).

We see that later efforts to blend and integrate science and engineering into a single curriculum and proposed guidelines had similar features. In the US the National Research Council's (NRC) 2012 report establishes relationships between the STEM fields from an engineering perspective as follows (p. 27):

> The major goal of engineering is to solve problems that arise from a specific human need or desire. To do this, engineers rely on their knowledge of science and mathematics as well as their understanding of the engineering design process.

More recently, a consensus report of the National Academies of Sciences, Engineering, and Medicine in the US has produced conclusions recommendations for STEM education. I also see a strong correlation between our past course implementations and their conclusions. For example, while defining students' role during learning in a STEM environment the report asserts the following conclusion (p. 4):

> Engaging students in learning about natural phenomena and engineering challenges via science investigation and engineering design increases their understanding of how the world works. Investigation and design are more effective for supporting learning than traditional teaching methods. They engage students in doing science and engineering, increase their conceptual knowledge of science and engineering, and improve their reasoning and problem-solving skills.

Years of such experiences at PSU as briefly sketched above helped me gain and develop insights and experiences for implementation of STEM education relevant for non-science majors and also for young pupils. After completion of PhD in 2001, I returned to Turkey to take a faculty position at Gazi University. In 2003, The Board of Education of the National Ministry of Education launched an ambitious nationwide program for curriculum reform. I was invited to take a position as an expert in the science curriculum development group together with several other academics and teachers. There I could find an exciting opportunity to influence my fellow working group members and the decision makers (the chairman and members of the Board of Education) in order to bring in fresh new ideas into science curriculum that I learned on the other side of the big ocean. During our 2-year efforts in curriculum development between 2003 and 2005, we also examined school science curricula of mainly the English speaking countries. We saw that even at during that time many US and Australian states together with England & Wales, and Ireland had already infused ideas and elements of STEM into elementary and middle school science curricula. However, during those early years STEM was not a daily word that educators and/or people on the streets knew and used. On the other hand, infusion and integration of technology/engineering design for teaching and learning science were apparent. We introduced those modern ideas to Turkey. As a result, for the first time in our modern day history for grades 4-8 the course name was changed from 'Knowledge of Science' (Fen Bilgisi) to 'Science and Technology' (Fen ve Teknoloji). Since then my impression has been that, since then, the 2005 science curricula, which had been in effect until 2013, it has been the most liked and preferred curriculum in the science education community including teachers and researchers. In 2013, a new curriculum has been introduced by wiping off STEM ideas and elements from the curriculum and renaming the course 'Natural Sciences' (Fen Bilimleri). However, with internationally increasing visibility of the, now what we can call, STEM Movement has forced reintroduction of some STEM ideas into the science curricula, although very vaguely, in 2018. In this story from Turkey, we see one example of how the international trends (or popularity) are influencing a nation's educational agenda.

Secondly, in this editorial, I wish to take a look at the landscape of STEM education journals worldwide. By that what I mean is, most likely, where to find articles related to STEM education. **Table 1** shows that STEM is a relatively new "word" to appear in journal titles. The oldest journal I could track by name was launched in year 2000. And looks like gained popularity in the second half of the 2010's. Previously an article that could be categorized under STEM education could be published in one of the journals specializing separately on either one of the fields of science education, mathematics education, technology education, and mostly university level engineering education. We see in **Table 1** that firstly dual combinations of two fields of STEM appeared in journal titles. Then a wave of triple fields appeared: "mathematics, science, and technology education" journals, but still without any visibility of the acronym STEM. In fact, they do not claim to be STEM education journals, but rather, publish articles from any of the three fields as they are somehow deemed to be related to each other. However, we also see that, when one examines authors' backgrounds, technology education people rarely contribute, if any, to these journals. These observations support the claims of Bryan & Guzey (2020) in this issue as to how the term STEM originated.

Additionally, after an analysis of the STEM literature (Chomphuphra, et al., 2019), it was found that STEM is more like a sub-domain of science education. Therefore, the answer to the question "Is STEM pushed forward by science education people?" is to a large extent 'YES.' The science education communities around the world believe in the merits of STEM education for learners and their countries. I appreciate the fact that it is extremely difficult to go beyond the traditions of a research paradigm to try out new things by reaching out to others, often times by involvement and engagement of unfamiliar people (almost like aliens) in unaccustomed (foreign) territories. Especially if one's agenda is already packed, it may be regarded unnecessary and/or untimely. Researchers from the individual fields of STEM rarely cross boundaries and come together in conferences or in collaboration projects, and hence, rarely publish together. What's more, they rarely read each others' articles. To me, as one of the chief editors of this STEM journal and a science/STEM education expert, this is a great difficulty that we must try to overcome in order to learn from each other and to advance the field of STEM education. STEM education needs to be the child of all four fields; not the biological child of science education and the step child of the other three.

Table 1. Journals of STEM Education

Journal Title	Year Started
School Science and Mathematics	1901
Research in Science and Technological Education	1983
International Journal of Technology and Design Education	1990
Journal of Science Education and Technology	1992
International Journal of Innovation in Science and Mathematics Education	1997
International Journal of Science and Mathematics Education	2003
European Journal of Science and Mathematics Education	2013
International Journal of Technology in Education and Science	2017
African Journal of Mathematics, Science and Technology Education	1997
Canadian Journal of Science, Mathematics and Technology Education	2001
EURASIA Journal of Mathematics, Science and Technology Education	2006
International Journal of Education in Mathematics, Science and Technology	2013
Journal of STEM Teacher Education	2010
Previously "Journal of Industrial Teacher Education"	*1963- 2010*
Journal of STEM Education: Innovation and Research	2000
International Journal of STEM Education	2014
Journal of Research in STEM Education	2015
European Journal of STEM Education	2016
Journal of STEAM Education	2017
Journal for STEM Education Research	2018
Hellenic Journal of STEM Education	**2020**

I searched for "STEM Education" in Scopus.com within "Article title, Abstract, Keywords" without any limits. It yielded 3,163 documents of which 1,277 are being in the "articles" category. I include the list of journals that have published the highest number of articles in **Table 2**. Among these top 15 journals there is no dedicated 'mathematics education' journal. In the entire list of journals, the only one is ZDM Mathematics Education that has published 7 articles. Likewise, Journal of Technology Education and Journal of Engineering Education have published 13 and 11 articles respectively. On the other hand, there are several science education journals in the list and mostly science educators are contributing to the others.

Table 2. Journals that published highest number of STEM Education articles

Journal Title	Number Articles
Journal of Science Education and Technology	41
International Journal of STEM Education	37
International Journal of Technology and Design Education	25
Eurasia Journal of Mathematics Science and Technology Education	24
International Journal of Science Education	24
International Journal of Science and Mathematics Education	21
Cultural Studies of Science Education	19
CBE Life Sciences Education	16
International Journal of Engineering Education	16
Journal of Chemical Education	15
Journal of Research in Science Teaching	15
Journal of Technology Education	13
Journal of Engineering Education	11
Science Education	11
Computers in Human Behavior	10
TOTAL	298

Another place to track the origins of STEM education research is ProQuest Digital Dissertations. My search for "STEM Education" within "Anywhere except full text – NOFT" yielded 766 theses, the great majority of which having been done in the last decade. The oldest one is dated 1997 and entitled "Teaching and learning techniques in secondary school science education using a techno-science context of industrial technological problems" (McKenzie, 1997). Interestingly, "STEM education" is found nowhere in this thesis. The second oldest document found is entitled "Sense of belonging among women of color in science, technology, engineering, and math majors: Investigating the contributions of campus racial climate perceptions and other college environments" from 2007 (Johnson, 2007). "STEM education" is visible all around in this document. The author's perspective was to examine "the relationship between campus racial climate perceptions and other college environments to sense of belonging among undergraduate women of color in science, technology, engineering, and mathematics (STEM) majors." She goes on and indicates that "For the past 30 years, researchers and educators have struggled to understand the under-representation of women in STEM (science, technology, engineering, and mathematics) fields" (p. 1). This problem of recruitment of students from different backgrounds into STEM fields has indeed been the major starting point for STEM education and we understand that it was not new even in 2007 since the recognition of the problem dates back about half a century ago from now (perhaps we should even go back to the Sputnik era and "the race for space," when creation of modern curricula, textbooks, and instructional methods were major challenges in STEM education in order to bring excitement and revival of interest towards STEM fields.)

The purpose of the analysis above was to show and alert stakeholders that we need more collaboration between educators and researchers who have backgrounds in the individual STEM fields. STEM education should not be a sub-domain of science education, nor should science education people dominate it. This assertion highlights the importance of integrated STEM education done in collaboration, not in isolation.

Introducing the Hellenic Journal of STEM Education

The Hellenic Journal of STEM Education is born and published by a long time collaboration between iSER (The International Society of Educational Research) and E3STEM (Hellenic Education Society for S.T.E.M.) as a new international forum for dissemination of scholarly works in STEM education. The two organizations believe in the value and importance of STEM education and wish to bring together their expertise and power to create a synergy in order to make a difference in STEM education perspectives and would like to see conversation on philosophical, theoretical, and practical aspects of STEM education.

My co-editor-in-chief and dear friend Professor Sarantos Psycharis has a deep interest in integrating 'arts' in STEM as well. He sees a lot of benefits in STEAM education as an enhancement of STEM. I agree with him to a large extent.

In this inaugural issue we begin with two reviews of the literature. Bryan and Guzey (2020) are starting with the origins of the STEM acronym and in reviewing the literature making a case for integrated STEM education by asserting that emerging studies are revealing that a positive impact is being created by integrated STEM on student learning of science and mathematics with a catalyzer role of engineering and technology.

On the other hand, a second review by Psycharis, Kalovrektis, and Xenakis (2020) is ending up by proposing a teaching and learning model which they name Computational STEAM Pedagogy (CSAP). The CSAP integrates the inquiry based teaching and learning approach, the Computational experiment spaces, the Engineering Education Epistemology (EEE) and STEM content transdisciplinary approach with an easy extension to include Arts. The CSAP model also integrates "the Computational Experiment for Education, the CPACK, the STEM content inter-disciplinary approach, the Engineering Education Epistemology, Art epistemology and the features of inquiry based teaching and learning approach."

The third article in this issue (Atasoy et al., 2020) deals with investigating 8th grade students' knowledge of biotechnology. Biotechnology is being compared to Artificial Intelligence and Nanotechnology in its capacity to build our future on the planet Earth. Increasing demand for food with increasing world population and technologies related to food preservation and creation of GMOs, applications in agriculture, waste treatment, and medicine are among its applications. Determining learners' existing knowledge base is important, since around the world modern curricula are including learning biotechnology as part of STEM education.

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