

PLANNING FOR ESTABLISHING STEM EDUCATION DEPARTMENT WITHIN FACULTY OF EDUCATION - AIN SHAMS UNIVERSITY AN INTERDISCIPLINARY MODEL

Dr. Hanaa Ouda Khadri

Faculty of Education – Ain Shams University, Cairo, Egypt

Abstract

The goal of the Egyptian Ministry of Education is to establish twenty-seven STEM schools over the course of five years . Teachers lack adequate support, including appropriate professional development as well as interesting and intriguing curricula. There is a real problem faces the Ministry of Education, that is the qualified STEM education teachers, in the main time there is no an academic department of [STEM] Education in the Egyptian universities preparing STEM education teachers , provide appropriate professional development and expand and enhance STEM Education in Egypt in significant ways. The objective of this Study is to propose a plan to Establish a Department [STEM] Education within the Faculty of Education - Ain Shams University.

Keywords: STEM Education , Disciplinarity , Interdisciplinarity , Multidisciplinarity, Transdisciplinarity

1.Introduction

There is growing concern in Egypt nationwide that students, teachers, and practitioners in the areas of science, technology, engineering, and mathematics (S.T.E.M.) are not adequately prepared. A majority of secondary school students are not proficient in Math and Science, and many are taught by teachers lacking adequate subject knowledge. S.T.E.M. education (and competitiveness) issues have received much attention in recent years. Several high-profile publications have been written and have catalyzed rigorous conversation among leaders in education, business, industry and politics. Many of these conversations have led to the conclusion that there is a need for reform in our Science and Math education systems to include S.T.E.M.

A specialized high school for students with exceptional talent in Math and Science is a relatively recent phenomenon in Egypt. Unfortunately, is the fact that the STEM school is not impervious to the Ministry of Education's policy and funding challenges. STEM education will determine whether Egypt will be able to solve immense challenges in such areas as energy, health, environmental protection, and national security. It will help produce the capable and flexible workforce needed to compete in a global marketplace. It will generate the scientists, technologists, engineers, and mathematicians who will create the new ideas, new products, and entirely new industries of the 21st century.

The goal of the Egyptian Ministry of Education is to establish twenty-seven STEM schools over the course of five years . This would mean one STEM school in each governorate. Schools often lack teachers who know how to teach Science, Mathematics, Engineering, And Computer Sciences effectively, and who know and love their subject well enough to inspire their students. Teachers lack adequate support, including appropriate professional development as well as interesting and intriguing curricula. School systems lack tools for assessing progress and rewarding success. Egypt lacks clear, shared standards for science and math that would help all actors in the system set and achieve goals (Noha 2013; Stacie Rissmann-Joyce ; Mohamed El Nagdi , 2013).

There is a real problem faces the Ministry of Education, that is the lack of qualified STEM education teachers, in the main time there is no an academic department of Science, Technology, Engineering, and Mathematics [STEM] Education in the Egyptian universities preparing STEM education teachers and expand and enhance STEM Education in Egypt in significant ways.

2. The Importance of the Study

In general, Egyptian Ministry of Education is facing big challenges to establish STEM schools, since it lacks qualified STEM education teachers, however establishing STEM Education Department will be a great opportunity to prepare (STEM) professional teachers in Egypt, and promote scholarship, engagement, and teaching that is innovative and contributes to improving the quality of education, especially in science, technology, engineering, and mathematics, in the nation .

3.Objectives of the Study

The objective of the study is to propose a plan to Establish a [STEM] Education Department within Faculty of Education - Ain Shams University.

4. Problem of the Study

The problem of the Study will be clarified through answering the following questions:-

1. What is S.T.E.M. and S.T.E.M. Education as an interdisciplinary area of study?
2. Why a Focus on STEM Education?
3. What are STEM School initiatives in Egypt ?
4. Why is STEM Education Department so important ?
5. What is the theoretical framework of STEM Education Department?
6. What are the phases of establishing STEM Education Department?
7. What is the administrative Structure of STEM Education Department?
8. What are the programs offered by STEM Education Department?

5-Methodology of the Research

5.1 The Source of Data

A. Secondary data: obtained through related references, and Faculty of Education and Ain Shams University documents (strategic plans, faculties programs , facilities, human resources, labs, ...etc.)

B. Primary data: collected through questionnaire that had been classified into three main parts.

- The first part prepared to collect basic data.
- The second part contained information about SWOT analysis.
- The third part contained information about the phases of establishing STEM Education Department, the administrative Structure, and programs offered.
- Interviews were conducted with STEM education teachers ,Faculty of Education and Ain Shams University leaders.

5.2 Sample of the Study

The Sample of the Study consists of Faculty of Education and Ain Shams University leaders, Science, Technology, Engineering and Mathematics faculty of the following colleges: Faculty of Education, Faculty of Engineering, Faculty of Science, Faculty of Computer and Information Science, and STEM education teachers .

6.Literature Review

6.1What is S.T.E.M. and S.T.E.M. Education ?

The problem is that research institutes, government organizations and occupational groups, as well as different groups involved in STEM use different definitions of STEM, based on their perspectives. Therefore, providing a clear and consistent definition and classification of STEM fields is necessary, not only for research, but also for measuring and improving

STEM education. Without a consistent definition, analyses between organizations may not reconcile and meta-analysis may be infeasible.

In the 1990s, the National Science Foundation (NSF) began using “SMET” as shorthand for “science, mathematics, engineering, and technology.” When an NSF program officer complained that “SMET” sounded too much like “smut,” the “STEM” acronym was born (Sanders, 2009). The National Science Foundation developed the word STEM as an acronym for science, technology, engineering, and mathematics. There are some who may use this acronym as the definition of STEM education. In other words, they would identify STEM by the separate subjects of which it is composed. However, this explanation is inadequate (Bybee, 2010; Salinger & Zuga, 2009). Rather, STEM education should be defined as an integrative approach to curriculum and instruction. It is best understood by removing any boundaries between the subjects and imagining them taught as one (Morrison & Bartlett, 2009).

S.T.E.M. is an acronym for **Science, Technology, Engineering and Mathematics**. These four content areas are, as a group, crucial to nation’s economic competitiveness and youth’s ability to succeed in the 21st century. The Colorado Department of Education describes STEM as,

“An interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering and mathematics in context that make connections between school, community, work, and the global enterprise, enabling the development of STEM literacy and with it the ability to compete in the new economy.” (Tsupros, Kohler, & Hallinen, 2009)

STEM education is a learning environment that Departments on students exploring, inventing, discovering, and using real world problems and situations (PCAST 2010). It encourages innovation by combining subject areas, which helps students make new connections between disciplines and sometimes helps create entirely new ones (Council on Competitiveness 2005). It creates real life learning opportunities for students. It promotes a learning environment for students to, not only learn 21st century skills, but also have the opportunity to create new skills (Narum , 2008). The National Governors Association’s (NGA 2007) Innovation America: Building a Science, Technology, Engineering, and Math [STEM] Agenda, describes STEM-based instruction as follows:

“STEM literacy is an interdisciplinary area of study that bridges the four areas of science, technology, engineering, and mathematics. STEM literacy does not simply mean achieving literacy in these four strands or silos. Consequently, a STEM classroom shifts students away from learning discrete bits and pieces of phenomenon and rote procedures and toward investigating and questioning the interrelated facets of the world.”

STEM Disciplines

STEM Disciplines are (The Arizona STEM Network 2013) :

Science instruction develops students' ability to use scientific knowledge (in physics, chemistry, biological sciences, and earth/space sciences) and processes not only to understand the natural world, but to participate in decisions that affect it (in three main areas — science in life and health, science in Earth and environment, and science in technology).

Technology instruction develops students' ability to use, manage, understand, and assess technology. Students should know how to use new technologies, understand how new technologies are developed, and have skills to analyze how new technologies affect us, our nation, and the world.

Engineering instruction develops students' understanding of how technologies are developed via the engineering design process. Lessons are project-based and integrate multiple subjects, making difficult concepts relevant and tangible to students and tapping into students' natural interest in problem-solving. Engineering design is the systematic and creative application of scientific and mathematical Basics to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

Mathematics instruction develops students' ability to analyze, reason, and communicate ideas effectively as they pose, formulate, solve, and interpret solutions to mathematical problems in a variety of situations.

First, it is important to distinguish between what S.T.E.M. education is and what it is not (Sorenson, Bernie 2010 , p.3)

S.T.E.M. EDUCATION IS . . .

- an interdisciplinary approach to learning that is rigorous and links student learning with real world challenges.
- an approach that emphasizes process and design with a goal to develop problem solvers and critical thinkers.
- a teaching method used to create a learning environment that promotes discovery, exploration, and problem solving.
- a move to drive S.T.E.M. literacy into the classrooms for ALL students.

S.T.E.M. EDUCATION IS NOT . . .

- a new name for the traditional approaches to teaching science and mathematics that rely primarily on lecture, worksheets, and cookbook-style labs.
 - the grafting of technology and engineering onto traditional science & math curricula.
- an emphasis on solution and replication of factual information.
- a movement to educate only the best and the brightest.
 - simply more math & science classes.

Goals of STEM Education

An appropriate understanding of STEM begins with an examination of its intended outcomes. The National Governor's Association Center for Best Practices recommends the following three Goals of STEM Education (National Governor's Association Center 2008, p. 16):

- ❖ STEM education prepares all students for the challenges and opportunities in the 21st century economy: In order to compete in the global economy, the next generation of students must have a strong knowledge of STEM – including an understanding of math, science, technology, engineering, problem-solving, and critical thinking skills – to succeed.
- ❖ STEM education improves the impact and overall effectiveness of the K-16 education system: Rigorous STEM education can help increase student achievement in multiple subject-areas, as it helps to develop critical thinking and analytical skills. STEM education is an important contributor to college- and career-readiness.
- ❖ A STEM-literate workforce adds value, productivity, and innovations to the economy: STEM-literate workers create a culture of innovation in business and are important contributors to economic development.

The President’s Council of Advisors on Science and Technology (PCAST 2012 ,pp. 15-17) identifies four major goals of STEM Education, By keeping these objectives in mind, educators can develop a set of practices intended to meet these specific goals.

1. Ensure a STEM-capable citizenry

This goal seeks to cultivate a citizenry that has “the knowledge, conceptual understandings, and critical-thinking skills that come from studying STEM subjects.” This is important even for those who never directly enter a STEM-related career.

2. Build a STEM-proficient workforce

This goal seeks to adequately prepare a sufficient number of workers for job openings in STEM-related careers which are expected to increase in coming years. Additionally, STEM-related skills are increasingly relevant in fields not directly related to STEM subjects.

3. Cultivate future STEM experts

This goal aims to educate the best STEM experts in the world because they contribute “to economic growth, to technological progress, to our understanding of ourselves and the universe, and to the reduction of hunger, disease, and poverty.”

4. Close the achievement and participation gap

This goal aims to increase women and minority participation and interest in STEM fields in order to tap into the country’s full potential.

STEM Subjects and Skills

Taken literally, the acronym “STEM” stands for science, technology, engineering, and mathematics. In the realm of K-12 education, STEM typically refers to coursework related to these disciplines. However, each of these categories may include instruction in several subject areas. The

following table outlines common STEM subjects in K-12 education: (TEMconnector 2011)

Science

- ❖ Biology
- ❖ Chemistry
- ❖ Marine Biology
- ❖ Physics
- ❖ Science

Technology

- ❖ Computer/Information Systems
- ❖ Game Design
- ❖ Developer
- ❖ Web/Software Developer

Engineering

- ❖ Chemical Engineering
- ❖ Civil Engineering
- ❖ Computer Engineering
- ❖ Electrical/Electronic Engineering
- ❖ General Engineering
- ❖ Mechanical Engineering

Mathematics

- ❖ Mathematics
- ❖ Statistics

In addition to these subjects, STEM may also include instruction in environmental science and geology though certain social and behavioral sciences (such as economics, anthropology, and sociology) may be appropriate STEM subjects at the postsecondary level, they are not typically addressed in K-12 education (PCAST 2010). Furthermore, most definitions of STEM education do not include references to the medical fields.

STEM schools

STEM schools are being developed across the nation, certain distinguishing design features emerge. STEM-focused schools tend to share the following four characteristics (Robelen, 2011):

- ❖ Small size
- ❖ Project-based learning
- ❖ Integrated curriculum
- ❖ Focus on serving underrepresented students

Combining early college models with STEM school models can facilitate moving from one level of education to the next (i.e. from secondary to postsecondary) and thus supports the STEM goal of developing a larger STEM proficient workforce. STEM schools that use an early college model

offer students college-level courses in high school. In some programs, students may graduate high school in five years with a high school diploma and an associate's degree. Naturally, this type of program relies on partnerships with higher education. For example, North Carolina's Learn and Earn early college high school provides a site at North Carolina Central University in Durham that offers college curriculum and work experiences with local biotech companies to provide students with an enhanced high school experience(National Governors Association 2007, p.18).

6.2 Why a Focus on STEM Education?

Knowledge-based economy is driven by constant innovation. The foundation of innovation lies in a dynamic, motivated and well-educated workforce equipped with (STEM) skills. However, the nature of our workforce and the needs of our industries have changed over time. Today, an understanding of scientific and mathematical Basics, a working knowledge of computer hardware and software, and the problem solving skills developed by courses in STEM are necessary for most jobs. Therefore, STEM education is an enormous and pressing need.(Leonard Gelfand Center for Service Learning and Outreach at Carnegie Mellon University And The Intermediate Unit 1 Center for STEM Education 2008)

The purpose of STEM education is to generate the next scientists, technologists, engineers, and mathematicians who will create new inventions and help lead the development of new 21st century industries (PCAST, 2010). STEM education inspires students to choose STEM careers like aerospace, architectural, biomedical, chemical, civil, electrical, and network engineers along with biological, chemical, CAD, construction management, mapping, simulator maintenance, and survey technicians. It encourages students to pursue occupations as a computer programmer, ecologist, environmental scientist, geologist, mathematician, meteorologist, statistician, zoologist, and a math, science, or technology teacher (North Dakota Department of Career and Technical Education, 2007). It helps creates new multi-disciplinary occupational fields—such as nanobiology, network science or bioinformatics (Council on Competitiveness, 2005, p. 42).

The President's Council of Advisors on Science and Technology (2010)report indicates thatSTEM disciplines have a common focus on problem solving and critical thinking. Although there may be some differences in specific problem-solving strategies in each of the four disciplines, there is far more common ground. Scientific Inquiry and Engineering Design both demand identification and clarification of a problem or question and a systematic approach to finding an answer or solution. Both involve reliance on empirical data and an iterative approach. Both also require a critical analysis of the results in terms of their meaning in

light of the problem or question. Mathematics and technology also have their discipline-specific strategies.

STEM as problem-based, interdisciplinary, and connected to a wide range of other disciplines. STEM problems easily emerge from global issues such as energy independence, green technology, and world food production. Solutions often tap into the historical record of past problems. Increasingly, the solutions to these problems have required a coherent and coordinated effort from all four disciplines in STEM. Many of the problems faced will require some form of engineered solution. However, those solutions will rely heavily on the knowledge base in science and mathematics as well as the analytical power of sophisticated technological tools (The Oregon STEM Education Initiative 2011).

The pace of modern economic competition dictates that no company or country can afford to stand still. Innovation, particularly through the application of science and technology, is central to maintaining productivity, economic growth. In turn, preserving and improving the nation capacity for innovation requires a growing number of innovators. (West ,Michael 2012).

6.3 STEM for the 21st Century

Today's world requires that all students obtain a solid foundation in STEM (science, technology, engineering and math). Gone are the days where students we deem non-college material are served best by teaching them to "work with their hands". Virtually every job requires proficiency in applied technology and a growing number of careers involve applied math and science. Moreover, it is the integration of STEM disciplines, the ability to apply knowledge to workflow along with 21st century skills such as communication and collaboration, critical thinking and problem solving, information literacy and adaptability that are most critical to success in a fast-paced global economy.

The Partnership for 21st Century Learning Skills(2011) identifies learning and innovation skills such as creativity, innovation, critical thinking, problem solving, communication, and collaboration. Applied to STEM education, this would mean that students will need to ask questions that can be answered through scientific inquiry, make sense of complex math problems, identify appropriate technological tools, and define engineering problems. These are unlikely to happen in a classroom solely focused on facts, algorithms, and tools.

6.4 STEM education as an interdisciplinary area of study

6.4.1 Interdisciplinarity:History

Roberta Frank (1988, cited in Klein, 1996, p. 8) places the origin of the term interdisciplinarity within the Social Science Research Council,

when the term was used as a kind of ‘bureaucratic shorthand’ for research involving two or more professional societies. However, the first citation in *Webster’s Ninth New Collegiate Dictionary* and *A Supplement to the Oxford English Dictionary* refers to a December 1937 issue of the *Journal of Educational Sociology* along with a notice for Post Graduate Fellowships for the SSRC (Klein 1996, following Frank 1988). Interdisciplinarity has since been promoted by several movements.

6.4.2 Disciplinarity and interdisciplinarity

Disciplinarity

As the concept of interdisciplinarity cannot be fully understood without an understanding of the the meaning and nature of disciplinarity is first clarified. To clarify disciplinarity appropriately , an inquiry into the nature of the disciplines should be the beginning . The term, ‘discipline’ etymologically links to the Latin term, *disciplina*, meaning ‘a branch of instruction or education; a department of learning or knowledge’ (*Oxford English Dictionary*, 1989: 734–5).

General characteristics of disciplines

For Aram (2004) disciplines are “thought domains—quasi-stable, partially integrated, semi-autonomous intellectual conveniences – consisting of problems, theories, and methods of investigation” (p. 380). They are quasi-stable because they are continually to the opening of new or revised ways of framing problems, theorizing, and investigating. Because most disciplines have core and peripheral elements as well as highly specialized sub-fields. partially integrated, because they have core and peripheral elements as well as highly specialized sub-fields , semi-autonomous, because the boundary of each discipline cannot be clearly defined.

Apostel (1972) goes so far as to say that “a discipline does not exist. A science does not exist. There are persons and groups practicing the same science or the same discipline.” (p. 147) In other words a discipline can only be defined by indicating:-

1. a group of persons
2. a set of actions, performed by these persons
3. a set of interactions or communications, among these persons and to other persons
4. a method of regenerating the set of persons by means of certain communications of an educational nature
5. a set of historic learning methods. (p. 146)

Types of interdisciplinarity

Although the terms multidisciplinary, interdisciplinary, and transdisciplinary are often used interchangeably, we believe it is worth establishing, as clearly as possible, some differences in meaning. To establish and clarify these differences, let us now consider the meaning of the prefixes ‘multi’, ‘inter’, and ‘trans’, when applied to the abstract noun ‘disciplinarity’.

The common uses of English, the prefix ‘multi’, from the Latin *multus*, means ‘many’ (‘multimillion’), ‘much’, ‘multiple’, ‘more than one’ (‘multiparous’). So, multidisciplinary refers to an activity associated with many, multiple, or more than one existing discipline. The Latin prefix ‘inter’ means ‘among’, as in the word ‘international’, or ‘together’, ‘mutually’ or ‘reciprocally’, as in the word ‘interchange’. Hence, interdisciplinarity refers to an activity that exists among existing disciplines or in a reciprocal relationship between them. But just as international relationships between different countries do not imply denying the sovereignty of each, interdisciplinarity would not negate the independence of each discipline. The Latin prefix ‘trans’ means ‘across’, ‘beyond’ (as in ‘transoceanic’ or in ‘transilient’), ‘transcending’ (as in ‘transubstantiation’), ‘through’ (as in ‘transpiration’) and ‘change’ (for instance as in ‘transliterate’). Following these meanings, transdisciplinarity is that which concerns transcending the disciplines, going across and through the different disciplines, and beyond each individual discipline.

In a penetrating analysis, Max-Neef (2005) identifies that a person may have studied, simultaneously or in sequence, more than one area of knowledge, without making any connections between them. One may, for example, become competent in Chemistry, Sociology and Linguistics, without generating any cooperation between the disciplines.

Multidisciplinary teams of researchers or technicians are common and frequent nowadays. In them, the members carry out their analyses separately, as seen from the perspective of their individual disciplines, the final result being a series of papers pasted together, without any integrating synthesis. Summarizing a body of ‘classic’ writings on interdisciplinarity, Klein and Newell (1998: 3) define interdisciplinary studies as, . . . a process of answering a question, solving a problem, or addressing a topic too broad or complex to be dealt with adequately by a single discipline or profession. . . . interdisciplinary draws on disciplinary perspectives and integrates their insights through construction of a more comprehensive perspective.

The conclusion to an entire book about interdisciplinarity is worth repeating here in terms of definitions:

Interdisciplinarity has been variously defined in this century: as a methodology, a concept, a process, a way of thinking, a philosophy, and a

reflexive ideology. It has been linked with attempts to expose the dangers of fragmentation, to reestablish old connections, to explore emerging relations, and to create new subjects adequate to handle our practical and conceptual needs. Cutting across all these theories is one recurring idea.

Interdisciplinarity is a means of solving problems and answering questions that cannot be satisfactorily addressed using single methods or approaches. Whether the context is a short-range instrumentality or a long-range reconceptualization of epistemology, the concept represents an important attempt to define and establish common ground (Klein, Julie Thompson, 1996 ,p. 196).

6.4.3 Key differences between Interdisciplinarity, Multidisciplinarity, Transdisciplinarity

A key difference between the terms *multi-* and *interdisciplinarity* is that interdisciplinarity refers to an, integrative process or relationship, whereas multidisciplinarity draws separately from several disciplines and is therefore simply an additive process. Interdisciplinary courses have been defined as "the work that scholars do together in two or more disciplines, sub-disciplines, or professions, by bringing together and to some extent synthesizing their perspectives" (Davis 1995, p. 5). In this paper the focus is on the interdisciplinary approach, which is characterized by flexibility, innovation, and the creation of new constructs for dealing with complex issues (Stone et al. 2009).

Bernard C. K. Choi and Anita W. P. Pak made an exhaustive literature review concerning the use of these three words. Their results seem to be compatible with the Latin roots of the prefixes:

Multidisciplinarity draws on knowledge from different disciplines but stays within their boundaries. Interdisciplinarity analyzes, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole. Transdisciplinarity integrates the natural, social and health sciences in a humanities context, and transcends their traditional boundaries. . . . The common words for multidisciplinary, interdisciplinary and transdisciplinary are additive, interactive, and holistic, respectively (Choi and Pak 2006, 351) .

Consequently, they recommend the following definitions:

- Multidisciplinarity draws on knowledge from different disciplines but stays within the boundaries of those fields.
- Interdisciplinarity analyzes, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole.
- Transdisciplinarity integrates the natural, social and health sciences in a humanities context, and in doing so transcends each of their traditional boundaries. (Choi and Pak 2006, 359)

In this paper, I will follow this well-grounded recommendation, and I will use "interdisciplinary" to refer to areas of educational research, knowledge, or theory that combine two or more disciplines.

Many academic and scientific institutions now recognize the need for an interdisciplinary education to prepare future managers, scientists, and leaders to solve complex socio-environmental problems (Ewel 2001, National Academy of Sciences et al. 2005). An increasing number of universities have added programs that support cross-disciplinary perspectives (Zarin et al. 2003, Rhoten, D., and A. Parker 2004).

STEM is not simply an acronym for Science, Technology, Engineering, and Mathematics; it represents not only disciplinary focus, but also a unification of the disciplines. It is its own entity and is much greater than the sum of its parts. The National Governors Association's (NGA; 2007) Innovation America: Building a Science, Technology, Engineering, and Math [STEM] Agenda, describes STEM-based instruction as follows:

“STEM literacy is an interdisciplinary area of study that bridges the four areas of science, technology, engineering, and mathematics. STEM literacy does not simply mean achieving literacy in these four strands or silos. Consequently, a STEM classroom shifts students away from learning discrete bits and pieces of phenomenon and rote procedures and toward investigating and questioning the interrelated facets of the world. (STEM) education often has been called a meta-discipline, the “creation of a discipline based on the integration of other disciplinary knowledge into a new ‘whole’. This interdisciplinary bridging among discrete disciplines is now treated as an entity, known as STEM (Morrison, 2006).

STEM education offers students one of the best opportunities to make sense of the world holistically, rather than in bits and pieces. STEM education removes the traditional barriers erected between the four disciplines, by integrating them into one cohesive teaching and learning paradigm. Morrison and others have referred to STEM as being an interdisciplinary approach. “STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply STEM in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Tsupros, 2009).” This author contends STEM education is greater than any interdisciplinary paradigm. It is actually trans-disciplinary in that it offers a multi-faceted whole with greater complexities and new spheres of understanding that ensure the integration of disciplines. This concept is further reinforced by Kaufmann (2003) and by the fact that new innovations and inventions today tend to be made at the boundaries of these four disciplines, where they naturally overlap. Biochemistry,

biomechanics, biophysics, biotechnology, and bioengineering are representative of the overlapping of the discipline we know as biology.

In fact, the connections between the four subjects in “STEM ”are very powerful and make it easy to build a logical case for treating them together as an interdisciplinary whole(David D. Thornburg , 2008).Ideally, STEM education should be more than interdisciplinary or multidisciplinary, even more than transdisciplinary. It should be metadisciplinary, or reflective of something that is coherent, comprehensive, and greater than the sum of its parts. When curriculum and instruction is interdisciplinary, multidisciplinary, or transdisciplinary, it is a combination of elements of the traditional disciplines, either in whole or part. STEM education is an intentional, metadisciplinary approach to teaching and learning, in which students uncover and acquire a cohesive set of concepts, competencies, and dispositions of science, technology, engineering, and mathematics that they transfer and apply in both academic and real-world contexts, in order to be globally competitive in the 21st Century (The Arizona STEM Network 2013) .

7.Egypt’s Stem Schools

The vitality of a country’s economy “is derived in large part from the productivity of well-trained people and the steady stream of scientific and technical innovations they produce. Without high-quality, knowledge-intensive jobs and the innovative enterprises that lead to discovery and new technology, our economy will suffer and our people will face a lower standard of living.” (National Academy of Sciences, National Academy of Engineering, and National Institute of Medicine 2007pp. 1-4.). Egypt is on the right track, but needs much support to make the STEM schools and their respective faculties and students successful. The idea of establishing a STEM school in Egypt was unbelievable during that critical stage of real political, economical and social change in Egypt, but it became a reality on August 2011 and the first Egyptian STEM School opened the doors to the Egyptian gifted students in Mathematics and Sciences regardless of their gender, social, or economic background.

Actually, the project – based learning environments are not known to many of the educational figures in the ministry of education in Egypt, therefore it is a new experience and learning approach to the Egyptian educational counselors, policy makers, school principals, administrators, teachers, students and their parents. “It was really very hard to start a project that you know nothing about” those words were regularly heard from the traditional Egyptian teachers who have been chosen to do an overloaded and a mysterious job (Noha, 2013). Discussions between the Ministry of

Education and USAID developed into the plan to establish (STEM) Schools, based on the American model promoted by USAID. The STEM schools program was introduced in Egypt during the 2011-2012 school year ,and there is a need for Faculty professional development must be on-going. There should be some sort of a liaison between these STEM schools (Stacie Rissmann-Joyce ; Mohamed El Nagdi , 2013).

7.1STEM School for Boys

The STEM School for Boys was founded on September 17, 2011 in the Global Village by his Excellency, Dr. Ahmed Gamal El-Deen, the Minister of Education for Egypt. The school continues to be supported through the generous support and stewardship of his Excellency Mr. Gamal Al-Araby, who was named the Minister of Education for Egypt in early 2012. The STEM School for Boys is located in the distant Cairo suburb called The 6th of October.

The goals for this STEM school were identified as well as the school mission as follows(Stacie Rissmann-Joyce ; Mohamed El Nagdi , 2013):

GOAL 1: Students must demonstrate a deep understanding of the scientific mathematical and social dimensions of Egypt’s grandest challenges as a country.

GOAL 2: Students must demonstrate understanding of the content and ways of knowing that display scientific, mathematical and technological literacy and subject matter proficiency.

GOAL 3: Students must exhibit self-motivation, self-direction and a hunger for continued learning.

GOAL 4: Students must exhibit the ability to think independently, creatively and analytically.

GOAL 5: Students must exhibit the ability to question, collaborate and communicate at a high level.

GOAL 6: Students must demonstrate the capacity to become socially responsible leaders

GOAL 7: Students must be to apply their understanding to advance creativity, innovation and invention with a real world vision with a consciousness and eye toward a more contemporary Egypt.

GOAL 8: Goals 1 – 7 must be implemented and viewed through the lens of a digital platform. Students must become fluid with technology to ensure that they maximize digital methods of data storage and communication.

Mission

The school seeks

- 1.To develop partnerships with universities, research Departments, factories, companies and those who care about education for developing, training and application for student and teacher learning.
- 2.To be linked with the latest innovations and research issues in a lifelong culture and to work as a team with the students and the teachers.
- 3.To develop the elements of innovation and creativity as an essential goal and to shed light on the role of science and engineering in the development of Egypt and the world.
- 4.To provide technical and financial support for the student-based learning focused on inquiry, projects and working as a team.
- 5.To conduct ongoing evaluation of all student and teachers while concentrating on developing the highest skills and self-reliance possible

7.2 STEM School for Girls

The STEM School for Girls opened its doors a year after the boys' school and has the same goals and mission. Students at both schools are acquiring the 21st Century Skills of communication, creativity, critical thinking and collaboration. It appears that both STEM schools are addressing every element of the school mission statement. The American University in Cairo, USAID, and World Learning are partnering with the STEM schools to enhance this innovation.

The school year contains two capstones in addition to the exhibition. A capstone consists of integrated units based on “the big idea.” It could be in the form of a concept, theme, theory, issue, problem, process, paradox, and perspective. The units of the capstone are designed and operationalized by the teachers of the different subjects in integration among subjects aligned with national standards to engage students in inquiry, exploration, self-learning, investigation and application through rubrics that guide students. Each capstone has a product that a student creates and attempts to achieve mastery through guided rubrics. To make a meaningful difference for student interest and persistence in STEM, schools must engage in a comprehensive approach that is research-driven. Unfortunately, both Egyptian STEM schools have a library, but insufficient for research. English as a primary mechanism to aid its students in becoming global citizens who are economically competitive. The school wants to ensure that its graduates are bilingual, speaking both Arabic and English. The study of English at the STEM schools is evolving with support by the British Council (Stacie Rissmann-Joyce ; Mohamed El Nagdi , 2013)

8. Why is STEM Education Department so important ?

The Graduate School of Education at the American University in Cairo has established a STEM Center. This initiative will provide professional development for STEM school educators, conduct action research at STEM schools, and assign graduate students to STEM schools for required fieldwork. The AUC STEM Center will be a first in the Middle East. As AUC has a signed Memorandum of Understanding (MOU) with the University of Minnesota's STEM Center, cutting edge educational research and practices will be available to boost STEM student achievement in addition to faculty development in inquiry-based teaching and project-based assessment strategies. Ain Shams University educational system has made enormous strides in many areas. Unfortunately, STEM education is not one of the areas in which Egypt has made progress. In fact, plan to organize a department with its joint appointments of faculty from Arts& Sciences, Technology, Engineering, and Engineering. It is also recognized that the necessity to secure STEM Education as a department within the Faculty of Education since it is intimately connected To other social sciences through institutional structure of Ain Shams University .

The new STEM Education Department would serve as the focal point to significantly increase the recruitment, preparation, and retention of highly qualified STEM teachers. In addition, the new department would improve significantly student success in mathematics and science by providing ongoing internationally-recognized best practices in professional development to practicing teachers and school leaders, and conducting extensive educational research on learning. To succeed in the is new information-based and highly technological society. All students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past. This department will ensure that our students graduate with strong content and teaching certificates, and are ready to meet national demands for highly qualified STEM teachers. This new department is designed to meet the demands through a student-Departmented, personalized learning system.

Faculty of Education will be positioned as a national leader in this area. The newly approved STEM Education graduate program is the first program developed under the auspices of the new department. The program offers teachers and other individual with expertise in one or more STEM fields opportunities to extend their learning in their domain, or to develop a broad background in STEM education. The new Department of STEM Education will provide Faculty of Education the ability to focus on programs to foster growth and expertise in the STEM education fields. Faculty of Education has so many current programs and non-STEM priorities.

With this new STEM focus, Faculty of Education will be able to concentrate on creating more highly qualified STEM teachers via innovative new programs and initiatives. One of the first actions of the department is to create an undergraduate program, which stands for Producing STEM education Leaders for Rural/Urban Schools. Currently, there is not an undergraduate program that provides teacher certification in the mathematics, science, Engineering or computer sciences areas. This program will include much field-based coursework and experiences.

At the core, science involves the “scientific method,” a process of hypothesis formulation and verification that is taught to students at multiple grade levels. Engineering, on the other hand, has at its core the more flexible notions of creativity and innovation – attributes that are harder to quantify and teach, but that are essential in the engineering domain nonetheless. The creative process can be nurtured, but it takes a special effort and classroom climate to stimulate creativity. This does not mean that the scientific method is not of value to engineers, nor that scientists can not benefit from creative insights. Links of this sort are legendary in both fields. It is just that, at the core of these fields, each of these ideas has a strong role to play (David D. Thornburg , 2008).

Science benefits from engineering, and engineering applies science – the two are linked. In fact, the linkages between these topics and the remaining STEM areas (technology and mathematics) are dynamic, highly interconnected, and constantly evolving over time. The interrelated nature of all the STEM subjects and the necessity of implementing an interdisciplinary approach rather than treating the individual subjects as “silos.” (David D. Thornburg , 2008, p. 3). The interactions between science and engineering with the remaining STEM topics (math and technology) are also fairly clear. Math skills are essential for both scientists and engineers. By the same token, advances in science and engineering can stimulate the development of new mathematical techniques. For example, Newton's contributions to physics and the calculus are tightly linked. Calculus provided the computational framework through which the laws of motion could be quantified and applied. This has always been the case. Geometry, for example, literally derives from “measure the earth.” While there are branches of mathematics that have yet to find application in science and engineering, this does not mean that applications will not be found at some time in the future (David D. Thornburg , 2008, p. 3) .

9.Theoretical Framework of STEM Education Department

All endeavors will be framed with a transdisciplinary design. We define *transdisciplinary* as engagement, investigation, innovation, and praxis addressing present -day issues and problems in a way that explicitly

highlights discipline commonalities while respecting disciplinary expertise and practice within and across STEM (Thompson Klein et al., 2001; Nicolescu, 2002).

9.1 Mission Statement for the Department of STEM Education

The mission of the Department of STEM Education at Faculty of Education - Ain Shams University, is to create more science, technology, engineering, and mathematics (STEM) professional teachers in Egypt, and promote scholarship, engagement, and teaching that is innovative and contributes to improving the quality of education, especially in science, technology, engineering, and mathematics, in the nation, and the world. Thus, the STEM Education faculty work collaboratively together and across our content areas to achieve excellence in teacher education development and practice.

9.2 The Department Goals

1. Provide graduate education programs and opportunities for individuals interested in teaching in STEM schools.
2. Provide selected programs and services for precollegiate learners and their families.
3. Conducts quantitative and qualitative research on the teaching and learning of the STEM disciplines, the organization and impact of STEM-focused schools, and on STEM teachers' assessment practices.
4. Increase the number of students seeking STEM careers and to improve student achievement in Science, Technology, Engineering, and Mathematics (STEM) courses.
5. Facilitate the integration of STEM Best Practices through targeted teacher professional development.
6. Improve teacher classroom practice through content focused coaching.
7. Support the development of quality school and district leadership for STEM integration.
8. Cultivate strategic alliances among schools, community, industry and higher education to provide STEM resources and experiences for students and teachers.
9. Affect the economic growth of the community by elevating the science, technology, engineering, mathematics, and critical thinking skills of students to enable them to become stronger members of the global workforce.

10. Translates contemporary research into practice through professional development focused on core disciplinary teaching practice, integrated STEM pedagogy, and assessment practices.
11. Provides young people access to high-quality STEM learning opportunities such as extended summer learning experiences.
12. Add to the knowledge base by disseminating research findings from projects in the Department regarding effective and best practices for the education and professional development of STEM educators and STEM practitioners.
13. Serve as an incubator and foster collaboration among scholars in all areas of STEM education research.
14. Provide opportunities to explore pedagogical approaches related to transdisciplinary, inquiry-based education using both on-site and distance delivery of instruction.
15. Design, implement, and assess high-quality national, regional, and local outreach projects that:-
 - Inform K-12 students about the role of STEM in our world.
 - Inspire K-12 students to pursue STEM careers.
 - Prepare K-12 students' to study STEM at the college level.

The Department of STEM Education mission and goals also guided faculty as they designed and developed the new programs in STEM Education presented in the following section of this paper.

9.3 Three Phases for Establishing STEM Education Department

There are three phases of the proposed STEM Education Department. Below is an overview of each of the three phases with discussions of each.

Phase 1 (Immediate upon establishment of Department)

1. The establishment of a STEM Education Department within the Faculty of Education.
2. The movement of education faculty from the Faculty Departments to the new Department of STEM Education , and joint appointments for select STEM faculty in the Faculties of Arts, Sciences, Computer and Information , and Engineering .
3. The transfer of the current undergraduate mathematics and science secondary education programs (English) .

Phase 2 (February 2015 - February 2016)

1. The development, approval, and implementation of a new undergraduate certification program undergraduate students can major in STEM Education and a content area with secondary teaching certification in STEM subjects in just 4 years. In addition, a stand- alone STEM Education major will be created to allow for

greater flexibility and multiple pathways towards becoming a STEM teacher.

The STEM Education Department will submit an innovative undergraduate Secondary certification. Program participants will earn a Bachelors of Science in Education with A double major in STEM Education and their content major (i.e., mathematics, physics, chemistry, biology, earth science, physical science, computer science) with secondary teaching certification in just 4 years. In addition, a proposal for a STEM Education major will be submitted that will allow Faculty of Arts and Sciences and Faculty of Engineering students to add on secondary mathematics, science, and/or computer science certification to their current degree program.

The STEM Education major will serve as the secondary major within their Arts, Sciences, Computer and Information, or Engineering degree program. There currently does not exist an undergraduate certification option for secondary mathematics, Science or computer science students at Faculty of Education - Ain Shams University. This degree program and major will allow for greater flexibility and multiple pathways towards Becoming a STEM teacher.

The establishment of no cost joint appointments between faculty from the Faculties of Arts ,Sciences, Computer and Information, and Engineering .

Phase 3 (March 2016 –March 2017)

1. The STEM Education Department will build upon undergraduate certification program to create a unique master' s program.
2. The development, approval, and implementation of a new STEM Education doctoral program. (Prior to the development of this doctoral program, PhD Students are enrolled in the Interdisciplinary Educational Science program housed At the Faculty level.)
3. The STEM Education Department will build upon the STEM Education master' s program doctoral offerings in mathematics and science education to create a unique doctoral program for graduate students to pursue a PhD in science education, technology education, engineering education, and/or mathematics education.

9.4Administrative Structure of STEM Education Department

Within the new department structure (see Figure (1)below), there will only be the need to add the administrative duties of a department chair and a director of graduate studies. Entities represented in the organizational diagram below will have the following roles/responsibilities:-



Figure(1):Administrative Structure of STEM Education Department.

Faculty Board - The function of the board will be to work on the Faculty budget, staffing, and regular activities .

Faculty Dean - The Dean of the Faculty of Education and will have administrative oversight of the STEM Education Department . He will work to ensure that the goals and activities of STEM Education Department remain aligned with the academic programs in Faculty of Education.

Director of Graduate Studies- Director of graduate studies (DGS) represents the department chairpersons and faculty in coordinating graduate programs in their respective departments. The Associate Dean for Research and Graduate Studies serves as the liaison across departments in the College and with the Graduate programs. Specifically, DGS communicates and works directly with the graduate programs staff, coordinate the recruitment of students, facilitate admissions and retention decisions, and assign advisors and advisory committee members. He is also required to maintain official student files. DGS serves as members of the Committee on Graduate Admissions and Standards. The purpose of this committee is to facilitate communication across programs and address mutual concerns

Director of Undergraduate Studies- Directors of undergraduate studies (DUS) represent the department chairpersons and faculty in coordinating undergraduate programs in their respective departments. The Associate Dean for undergraduate studies serves as the liaison across departments in the Faculty and with the undergraduate programs. Specifically, DUS communicates and works directly with the undergraduate programs staff, coordinate the recruitment of students, facilitate admissions and retention decisions, and assign advisors and advisory committee members. He is also required to maintain official student files. DUS serves

as members of the Committee on Undergraduate Admissions and Standards. The purpose of this committee is to facilitate communication across programs and address mutual concerns

Advisory Board -This group will be composed of representatives from the Faculty of Arts, Sciences, Computer and Information , and Engineering and representatives from partnering institutions. The Advisory Board will meet annually to review the progress of the STEM Education Department and to provide input regarding the general direction for the Department to take in the following year. Members of this Advisory Board will be nominated by the Faculty of Education dean, and the faculty board. Board of Advisors will serve two year terms and may be re-elected.

Department Chair- The STEM Education Department Chair will be in charge of running STEM Education programs, overseeing staff, and working with faculty to develop and run programs. The department chair will also be the Faculty of Education primary representative for STEM education.

STEM Program Director

The Director of the STEM Program is responsible for the organization, planning, implementation, continuous review, and analysis of the Faculty's STEM Program Connections and works closely with Department Chairs, Associate Deans/School Directors, Academic Deans, Campus Presidents and all STEM Program partners.

Essential Duties and Responsibilities

- ❖ Administers and manages the programs funding including preparation and maintenance of the budget for STEM Program to assure that program efforts comply with the requirements of the funding source.
- ❖ Works closely with Faculty staff in the development of instructional methods and tools to implement peer-tutoring program.
- ❖ Oversees work with local high schools to develop assessment and support materials to enhance participation in STEM education.
- ❖ Hires, supervises, evaluates both full-time and part-time personnel for the program.
- ❖ Collaborates with partners and participation in the Summer Research Mentoring on campus and Faculty-wide committees.

STEM Program Coordinator

STEM Program Coordinator is responsible for the planning, development, and management of STEM student related activities. provides academic leadership, serves as an integral member of the Faculty.

Essential Duties and Responsibilities

- ❖ Works closely with STEM department Chairs, Directors, and Deans and assists the Director with the preparation of all Student reports .
- ❖ Trains and coordinates joint faculty-student services personnel for improved advisement in STEM as requested .
- ❖ Mentors, tutors and advises STEM students .
- ❖ Establishes a permanent joint Academic Affairs-Student Services Committee for STEM.
- ❖ Oversees development of support materials to enhance student recruitment and retention.
- ❖ Establishes student databases, internships, and job placements to meet program goals and grant reporting requirements as assigned .
- ❖ Identifies and works with STEM constituents to establish outreach activities and employer pipelines for students .
- ❖ Coordinates collaborative efforts with Schools to include High School partners to help deliver STEM-related activities .
- ❖ Assesses student retention and identifies need for interventions.
- ❖ Monitors and documents project progress.
- ❖ Provides opportunities for engagement strategies into target STEM pedagogy.
- ❖ Assists in the project evaluation and oversees the service learning and the problem-based learning components.
- ❖ Establishes articulation agreements with other universities.
- ❖ Performs other duties as assigned.

Faculty - The STEM Education Department will have Faculty to implement STEM Education programs. Faculty electing to participate in STEM Education Department will agree to:

- ❖ Draw upon the resources of Faculty of Education to assist with the development, submission and implementation STEM of Education programs.
- ❖ Participate in the Faculty of Education governance and/or decision-making processes.
- ❖ Participate in efforts to formulate and re-formulate the strategic plan
- ❖ Inform the annual evaluation of Faculty of Education staff.

Joint Appointments

It is needed to have no cost joint appointments within our proposed STEM Education Department for select STEM faculty in the Faculties of Arts, Sciences, Mathematics , Computer and Information , and Engineering.

9.5 Program Structure within Science, Technology, Engineering, and Mathematics Department

The STEM Education department would have representation on Faculty-level committees and be treated as other departments in the Faculty .
 Table (1,2,3,4,5,6): Courses to be created in the STEM Education Department .

Table (1)
 Bachelor of Science in Education
 Double Major in STEM Education
 Required General Education Core: (31 hours)
 May overlap with content major requirements. May not overlap with Content Support courses.

Course	Title	Term	Grade	Credits
Intellectual Inquiry	The Basics of Inquiry in the Natural, Physical, & Mathematics Sciences			3
	The Basics of Inquiry in the Social Sciences			3
	The Basics of Inquiry in the Humanities			3
	The Basics of Inquiry in the Arts & Creativity			3
Communications	Writing I			3
	Communication			3
Quantitative Reasoning				
MA 130 or MA 154	Mathematical, Logical and Statistical Foundations			4
STA 227	Statistical Reasoning			3
Citizenship	Egypt Citizenship			3
	Global Citizenship			3
Required STEM Education Major Core:				

Course	Title	Term	Grade	Credits
SEM 110*	Introduction to STEM Education			2
EDP 202*	Human Development and Learning			3
EDS 516*	Basics of Behavior Management and Instruction			3
SEM 438*	STEM Methods I			3
SEM 439*	STEM Methods II			3
SEM 442*	STEM Student Teaching in the Secondary School			10
EPE 318W*	Education and American Culture			3

* Requires field experience hours

Table (2)
Specialization STEM Content Coursework.Mathematics

Course	Title	Term	Grade	Credits
Mathematics Core Courses				
MA 130+	Calculus I			4
MA 131	Calculus II			4
MA 230	Calculus III			4
MA 278	Introduction to Number Theory			3
MA 339	Matrix Algebra and its Applications			3
<i>Mathematics Sequence, Choose one. May substitute a different sequence with prior faculty approval.</i>				
MA 378	Elementary Modern Algebra I AND			3
MA 379	Elementary Modern Algebra II			3
MA 425	Basics of Operations Research AND			3
MA 424	Basics of Operations Research II			3
Required Mathematics Electives				
MA 327	Mathematics Problem Solving for Teachers			3
MA/STA 337	Introduction to Probability			3
MA 347	History of Mathematics			3
MA 358	Topics in Geometry			3
Optional Courses				
MA 221	Calculus IV			3

Table (3)

Course	Title	Term	Grade	Credits
Physics				
CHE 122+	General Chemistry I			3
CHE 114+	General Chemistry II			3
PHY 248	General University Physics			4
PHY 249	General University Physics II			4
PHY 235	Optics, Relativity, & Thermal Physics			3
PHY 317	Theoretical Methods of Physics			3
PHY 342	Data Analysis for Physicists			3
PHY 378	Basics of Modern Physics			3
PHY 418G	Special Topics in Physics and Astronomy for elementary, middle school, and high school teachers			3
PHY 477W	Active Learning Laboratory for Secondary Majors			4
AST 327	Topics in Astronomy and Astrophysics			3
MA 127+	Calculus I			4
MA 131	Calculus II			4
MA 131	Calculus III			4

STEM Content Support Courses – the student takes up to 120 hours required for graduation the student select from each area of interest. He may not double count these courses with his major content course requirements or General Education requirements. Students should take courses in the STEM areas outside of their content/certification area. This list is not inclusive. All courses should be approved by advisor before taking.

Table (4)

Course	Title	Term	Grade	Credits
Mathematics/Statistics				
STA 307	Statistical Method			3
MA 518/519	Seminar in Selected Topics			3
OR/STA 531	Probability			3
EDC/EDP/EPE 539	Educational Tests and Measurements			3
SEM 532	Mathematics Clinic			3
Engineering				
EGR XXX	Sys STEM			3
EGR 118	Introduction to Engineering			4
EGR 208	Technology and Society			3
EGR 206	Global Energy Issues			3
Technology				
CS 122	Introduction to Computer Programming			3
TEL 218	Communication Technologies and Society			3
INF 418G	Fundamentals of Informatics			3
EDC 560	Digital Game Based Learning and Instruction			3
EDC 561	Use and Integration of Instructional Media			3
CS 232	Introduction to Program Design, Abstraction, And Problem Solving			3
CS 238	First course in computer science for engineers			2
CS 333	Web Programming			3
Science				
CHE 112	General Faculty Chemistry I			3
CHE 128	General Faculty Chemistry Lab I			3
BIO 155	Basics of Biology I			3
BIO 162	Basics of Biology Laboratory I			3
PHY 248/258	General University Physics			3
PHY 258	General University Physics Laboratory			3
GLY 237	Basics of Physical Geology			3
Total Credit Hours				
Minimum 120 credit hours required for graduation .				

Table (5)

Masters of Science in STEM Education

Master’s of Science in STEM Education program designed to address expanded leadership expectations, especially in the content areas of science, technology, engineering, and mathematics, for practicing educators in schools across Egypt.

Core Courses

Masters of Science in STEM Education

SEM 620	Curriculum and Instruction in STEM Education
SEM 611	History of STEM Education
EDC 617	Instructional Design I
SEM 627	Teacher Leadership in STEM Education
SEM 630	Effective Use of Technology for Modeling-Based Inquiry in STEM Education
SEM 637	Equity in STEM Education
SEM 687	Advanced Elementary Mathematics Methods (required)
SEM 691	Advanced Studies in Teaching Elementary School Science
SEM 692	Mathematics Clinic
SEM 718	History of Mathematics Education
SEM 711	Designing Project-Enhanced Environments in STEM Education
SEM 713	Research in STEM Education
SEM 715	Engineering in STEM Education
SEM 787	Special Topics in STEM Education

Ph.D. in STEM Education

The Education Sciences Interdisciplinary Ph.D. with an emphasis in Science Education and Mathematics Education is an intensive program designed to prepare future researchers, teacher educators, and researcher-practitioners to meet the national call for more individuals with heightened scholarly expertise in STEM Education.

Table (6)
Core Courses
Ph.D. in STEM Education

SEM 127	Introduction to STEM Education
SEM 345	Teaching Science in the Elementary School
SEM 354	Teaching Mathematics in Elementary Schools
SEM 362	Teaching Mathematics in the Middle Schools
SEM 365	Teaching Science in the Middle School
SEM 438	STEM Methods I
SEM 439	STEM Methods II
SEM 442	STEM Student Teaching in the Secondary School
SEM 462	Applications of Teaching Mathematics in the Middle School
SEM 592	See Blue Mathematics Clinic
SEM 610	Curriculum and Instruction in STEM Education
SEM 621	History of STEM Education
SEM 627	Teacher Leadership in STEM Education
SEM 630	Effective Use of Technology for Modeling-Based Inquiry in STEM Education
SEM 637	Equity in STEM Education
SEM 648	Mathematics Pedagogy in the Secondary School
SEM 651	Science Pedagogy in the Secondary School
SEM 687	Advanced Elementary Mathematics Methods
SEM 691	Advanced Studies in Teaching Elementary School Science
SEM 718	History of Mathematics Education
SEM 719	Theoretical Foundations of Mathematics Education
SEM 720	Advanced Research in Mathematics Education
SEM 721	Designing Project-Enhanced Environments in STEM Education
SEM 713	Research in STEM Education
SEM 726	Engineering in STEM Education
SEM 763	Subject Area Instruction in the Secondary School
SEM 765	Master's Thesis Research
SEM 784	Dissertation Residency Requirement
SEM 797	Special Topics in STEM Education
SEM 798	Independent Study in STEM Education

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