Science, Mathematics and Engineering Education in 2040

1.0 Preamble:

This is an idea paper on science, technology, engineering, and mathematics (STEM) education, as we know it today. The goal is to propose an evolutionary not revolutionary model, recognizing the enormity of the STEM education enterprise. Another key observation here is that the U.S. STEM education system is strong in its rigor and effective in its imparting education today; the goal then is to build on the strengths of this education system.

2.0 Areas for Change:

There are five areas for change: (i) redefining the four core disciplines, (ii) a new undergraduate program structure, (iii) creation of a national undergraduate lab network, (iv) creation of a national makerspace network, and (v) creation of a cadre of undergraduate teaching faculty.

Over the recent decades of the last century, undergraduate level education in STEM areas have emphasized theoretical treatment of topical areas. An impactful change in the study of the STEM areas would be to emphasize a context focus alongside the topical focus. This leads to change (i). Change (i) leads to a need for a new undergraduate program structure along with changes in the delivery for the current and future student population. This leads to change (ii). Labs are vital to education in some STEM disciplines, while labs and student-accessible making facilities are necessary for others. These labs and making facilities adequately staffed require appropriate spaces and significant initial investments and periodic upgrades in hardware, software, and personnel. A large number of universities fall short on providing state-of-the-art experiences in such facilities for their students. Changes (iii) and (iv) address this important need. The long-standing faculty model of serving undergraduate programs along with building graduate program and a research program, is largely a failure; for individual faculty, it has often led to some neglect of undergraduate education or to a poor research record. Change (v) addresses this issue.

2.1 Refining the core disciplines:

The undergraduate programs with “Science” topical focus is proposed to have an additional focus in “experimentation”; this would recognize this discipline as being uniquely prepared in “experimentation”.

The undergraduate programs with “Mathematics” topical focus is proposed to have an additional focus in “modeling”; this would recognize this discipline as being uniquely prepared in contemporary “modeling”.

The disciplines of technology and engineering have a significant overlap, often leading to confusion in the subject matter in the two disciplines. It is proposed that Technology and Engineering be collectively called Engineering. The undergraduate programs with “Engineering” topical focus is proposed to have an additional focus in “building solutions”; this would recognize this discipline as being uniquely prepared in “building solutions”.

2.2 A New Undergraduate Program Structure:

Figure 1 presents a new broad undergraduate program structure with the redefined disciplines. Each discipline has context focus in additional to the traditional topic focus. The expectation here is that the discipline will seek to educate and train the student in both the topic and context as stated in Figure 1.

An undergraduate in “Science and Experimentation” will be educated and trained in science and experimentation; field work and labs will provide the context for a significant part of the education.

An undergraduate in “Mathematics and Modeling” will be educated and trained in mathematics and modeling; multiple historical and contemporary problem domains will provide the context for a significant part of the education.

An undergraduate in “Engineering by Analyzing, Designing, and Building” will be educated and trained in science and mathematics-based analysis, design, and building; understanding customer / user needs will provide the context for a significant part of the education.

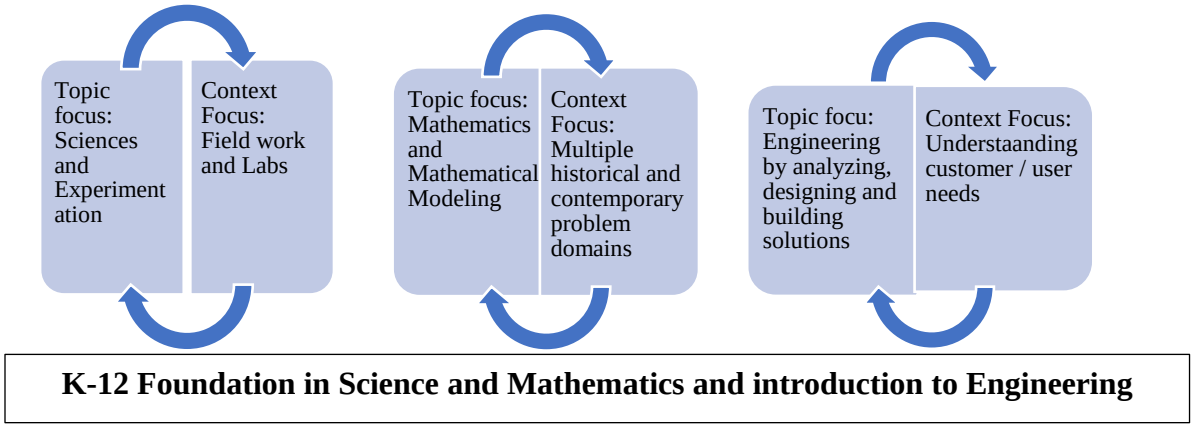

Figure 1. A new undergraduate program structure for Science, Mathematics, and Engineering

It would be important to retool the K-12 curriculum, to introduce the discipline of Engineering. This will have to be at a depth that will enable students to select or not select an engineering major.

In developing curricula, it is proposed a typical one semester be broken into two pieces. Programs should offer students to complete a course requirement via competency tests; this is to recognize that some learning may be accomplished by a students via a MOOC.

The preparation in context areas will have to be developed by faculy.

2.3 National Undergraduate Lab Network:

Loosely similar to national labs, it is proposed that federal government regional lab complexes be created across the country; the focus would be to house contemporary experimental experiences in science and engineering. Year-round short lab courses will be offered by these lab complexes for credit and would be transferable to any university. Faculty from universities will be offered the opportunity of serving as Instructors for short durations to provide them a valuable experience.

2.4 National Makerspace Network:

Analogous to the lab network, it is proposed that a network of regionally located makerspaces be created. These federal government-run facilities must be well- equipped with state-of-the-art machines and Instructors. These would offer fee-based courses and access to machines. Technical staff from universities will be offered the opportunity of serving as Instructors for short durations to provide them a valuable experience.

2.5 Undergraduate Teaching Faculty:

This effort is already underway in several universities. The undergraduate programs must have Instructors who are not expected to run a research program. The traditional tenure-track faculty must not teach in the undergraduate program.