Explaining The AMST Model: Using Arts, Maths, Science, and Technology in an Upgraded Problem-Based Learning Approach

Georgia DALEURE
General Studies Department, Higher Colleges of Technology
Sharjah, United Arab Emirates

Recent literature has touted the importance of the Science, Technology, Engineering, and Mathematics (STEM) curriculum model as the best way to develop a problem-based inquiry in the technology-rich, globally-connected 21st century learning environment. While this approach provides an interesting and valuable approach, not all students are excited, stimulated, and motivated by scenarios centered around engineering concepts; therefore, the model falls short of addressing important competencies that have little or no acknowledgement in the STEM curriculum model. The missing elements include the purpose and the consequences and developing the 21st century skills needed in knowledge economy jobs. By adding modules in which an arts discipline serves as the central point of the instructional scenario, students can be exposed to a broader range of interest provoking experiences. For lack of a better acronym, AMST is used representing the components of Arts, Math, Science, and Technology, to refer to a problem-based curriculum using arts-based central scenario components serving to support integrated sub-modules of maths, science (which may include engineering), information literacy, and computing technology.

Keywords: STEM curriculum, AMST curriculum, Arts, sciences, integrated curriculum model, 21st century skills, problem-based learning

INTRODUCTION

Recent literature has touted the importance of the Science, Technology, Engineering, and Mathematics (STEM) curriculum model as the best way to develop a problem-based inquiry in the technology-rich, globally-connected 21st century learning environment. Corlu, Copraro, and Copraro, steadfast supporters of STEM educational pedagogy, advocate its use in pre-collegiate students.[5] As explained by pioneer advocate, Rodger Bybee, "a true STEM education should increase students' understanding of how things work and improve their use of technologies" with the overall effect of increasing pre-collegiate students to engineering concepts.[3] Advocates of the STEM approach to curriculum design claim that learning through problem-based scenarios with engineering concepts, students develop such skills as adaptability, complex communication, social skills, non-routine problem solving, self-management, and systems thinking, i.e. 21st century skills, necessary to obtain and succeed in future jobs in the knowledge-based global economy. [8]

While this approach provides an interesting and valuable approach to tackling challenges of enhancing student learning and achievement of 21th century skill, is this the only way? Organizations such as the Washington, D. C. based think tank called The Information Technology & Innovation Foundation (iITIF), attribute the decline of the U.S. global market share in STEM-based industries to a declining number of American graduates of STEM-based programs, despite the fact that a large number of leading universities in the US offer STEM-based programs. [1]

The message has become so widespread and emphatic that a notion has developed among educational practitioners and curriculum developers that "STEM is so important that we can't afford not to have every student in America given the best STEM education, with the hope that this will increase the likelihood that at least some of them will go into STEM jobs." [1] The assumption with STEM supporters is that design technology positions are perceived to be highly lucrative and rewarding and creating a sense of urgency for a "STEM for all" mentality [9].

In response to this concept, two questions beg to be asked. The first question is, "What about the students who are not excited, stimulated, and motivated by scenarios centered around engineering concepts?" Students are individuals with their own personally unique set of skills, aptitudes, motivations, and career aspirations. The notion the educational curriculum model could be a one-size-fits-all – with engineering as the core – seems to imply that if a device or mechanism is not the product or the core upon which the curriculum is constructed, then the curriculum has not served a useful purpose. Some students, despite their own best efforts and the extraordinary efforts of their teachers, will not find interest or motivation in learning about devices or engineering concepts. The second question, which may be even more important is, “how employable, i.e. in demand, are graduates of engineering-based technology-driven programs?”

In attempting to address the issues raised in these two very obvious questions, this paper offers a potential solution in the form of curricula designed using the Arts, Math, Science, Technology (AMST) model and maps the learning outcomes of AMST core competencies to a wide variety of jobs that are needed in the 21st century globalized economy, jobs in which core competencies of engineering are not necessary. The aim of the paper is to highlight that students have different learning needs, aptitudes, interests, motivations, and career aspirations so multiple approaches to problem-based learning must be offered, especially at the primary and secondary levels, to assure that students are well rounded. Students must be able to contribute their own unique skills sets to the modern society that needs a variety of professions.

IMPORTANCE OF ARTS IN CURRICULUM DEVELOPMENT

The term “arts” represents the disciplines that have been excluded from in the STEM curriculum. Disciplines such as history, humanities, social science, and communication skills have been devaluated and even excluded in educational curricula at all levels of education in many countries around the world. Disciplines considered arts include spoken and written communication, languages, history, social science, psychology, literature, culture studies, ethics studies, and others. Arts disciplines attempt to explain human behavior, values, norms, transitions, conditions, and aspects that connect people into a web of humanity that is larger than the next technological gadget.

While engineering may provide the next generation of SMART phone, disciplines categorized as arts generate the discussion of the way the device affects society, or provide understandings related to policies that protect consumers and producers, or debate ethical issues associated with certain age groups being given access to practically unlimited access to all information that exists in the digital domain.

Society needs graduates that are familiar with basic concepts in the areas of science, information technology, and mathematics. However, do all students need to know about engineering concepts to live a productive modern life?

Recent introduction of the STEM model in educational curricula from primary through tertiary seems to imply the affirmative, while at the same time implying that concepts associated with disciplines loosely termed as arts, have little value as they are not included. [3]

This is rather shocking omission. According to a report produced by the Georgetown Public Policy Institute, projections for STEM-based jobs rank seventh in projected need for the 2020 job market behind sales & office support, blue collar, food & personal services, managerial & professional office, education, and healthcare professional & technical, respectively. [4] Even STEM curriculum advocate iITIF estimates that only 5% of the total college graduates need be equipped with engineering or Information Technology (IT) degrees to have a sufficiently innovative workforce in the US to complete economically on a global scale. [1] It is clear that a myriad of other employees are needed to carry the innovative ideas through to fruition and fuel the public and private sector economy in non-production sectors. [7]

Students must be educated in the missing elements including the purpose and the consequences. Should constructing and producing a new innovative product be done only because it is possible? Most would say, “no”. Questions need to be asked and answered before proceeding. Questions could include: Who will use this device and how will different segments of society react to it? Will this new technology challenge cultural and/ or religious values of those affected by it? What new legislation will be required to address monitoring the consequences of this new technology or managing waste or byproducts of this new technology? How will the introduction of this new technology be communicated to society at large? These may not be questions that engineers or IT specialist normally concern themselves with as specialists and innovators.

STEM CURRICULUM AND HIGH ACADEMIC ACHIEVEMENT

The last question that should be asked is, “Do students learn better in a STEM-based learning environment and how would better learning be measured”. Oner and Capraro tackled these questions in a study based in Texas, USA. Texas is known for early adoption of STEM curricula in public schools called T-STEM academies. Using a set of five benchmarks, the study found that at first (early years through middle school) students seemed to perform better on standard achievement tests but as the subjects because harder (around grade eight or nine) achievement test scores of T-STEM academy students decreased to scores similar to students in non-T-STEM academies. [9]

The rapid rise in students' early years then decline in higher level students, according to Oner and Capraro is most likely explained by two main factors. The problem-based learning method at the core of the STEM philosophy enabled students with a wide variety of natural interests and aptitudes to excel by increasing interest and motivation in subject matter. However, as the content (especially the math and theoretical engineering concepts) became more complex, only the students with the natural occurring aptitudes for those areas of study excelled while others' scores rapidly declined. [9]

Not all teachers and individuals have an innate love of math and science. Introducing STEM as the only curriculum model assume that all teachers possess skills sets that are compatible with providing STEM education. Teacher related issues have been identified as the most significant impediments to successfully implementing STEM curriculum in schools. The most common issues were the inability to secure funding to train teacher and the lack of interest or motivation among some teachers to embrace the concept. [8]

EXAMPLES OF ARTS CORE PROBLEM-BASED SCENARIOS

Consider the following scenario:

> A municipal government invested heavily in tax breaks and other incentives to bring high tech industries to the area with phenomenal results. Upon completion of the three-year plan, business was booming and the area became a bustling urban center. In the fourth year, however, newly hired, highly trained technical employees and engineers began tendering their resignations due to diminished quality of life. The resignations sent alarms through the upper management of several of the newly established businesses. A study commissioned by the municipal government found several reasons for this trend including the following:
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> Local property owners in the urban center dramatically raised rents to take advantage of the influx of new highly paid workers locating in the city. As rents rose, workers sought cheaper alternatives in the outlaying sub-urban areas. This was perceived at first to be a great secondary boost to the economy as it spurred development and improved real estate prices. However, as more and more workers relocated to the suburban areas, traffic at rush hour dramatically increased. Commuters noticed that a trip which only the year before took 30 minutes, increased to upwards of 1.5 to 2 hours depending on road conditions. In addition, extra trips such as dropping off children at school became impossible in traffic so private transport had to be arranged at additional cost.
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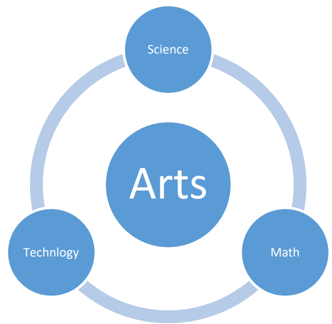
> When the results of the study were released, large employers began providing a shuttle service from the main employment locations to high density suburban centers. In addition, the municipal government developed and started implementing a low-cost public transport system. Funded partially by the increased property tax revenue, a new public school was built in the suburban area to accommodate residents in the rapidly expanding new area. These solutions enabled the companies to retain their valuable employees and continue the symbiotic relationship of economic progress with the municipal government.

In this scenario, a few of the economic players were the innovators with engineering or advanced IT specialist degrees, supporting the 5% estimate of Atkinson and Mayo.[1] Perhaps 5% of the new workers would have been highly trained engineers or IT specialists with the vast majority being more modestly educated and trained factory workers, business people to service the expanded population, vocationally trained service people such as plumbers, construction workers, mechanics, etc., and even more relatively low skilled service workers in areas such as food and entertainment, and general labor. It does not make the STEM workers more valuable than the others, it merely establishes a perspective on realistically achieving sustainable employment**. [2]**

By adding modules in which an arts discipline serves as the central point of the instructional scenario, students are exposed to a broader range of interest provoking experiences. For lack of a better acronym, this paper uses AMST representing the components of Arts, Math, Science, and Technology, to refer to a problem-based curriculum using arts as a central scenario component as shown in Figure 1.

Figure 1: AMST Model



The model shows depicts the arts disciplines as the nucleus of the "learning" experience with the science, math, and technology concepts revolving around the nucleus, supporting and enhancing the overall learning environment in an integrated and seamless experience.

Sample AMST Learning Scenario

Consider a scenario in which students receive brief input about rural to urban population migration (social science) to set up the core scenario. Student groups are given an electronic file containing 30 or so vital documents about a group of people including fictional birth certificates, death certificates, marriage certificates which students asked to construct a family tree from the documents using a specific software. The next step would be to construct an electronic timeline noting the birth dates, death dates, locations, and occupations from the documents. The next step would be to have students investigate the conditions of the birth places and death places as the time periods specified and write a narrative about what could have happened to the fictitious people in the file. The presentation could include tables calculating ages, distances between birth and death locations, and other statistics gleaned from internet sources supporting their narratives. This scenario illustrates that both math, natural science, and technology can be layered around an authentic and interesting problem-based scenario drawing out and enabling students to utilize critical thinking skills for something other than creating a gadget or product.

By framing the learning scenario in an arts discipline, students are exposed to a variety of thought processes that tie the science, math, and technology components together as integrative subjects.

CONCLUSION

Social science and historical scenarios can be as powerful and useful as engineering in setting up problem-based learning scenarios that tie together science, technology, and mathematics. The variety in problem based scenarios allows students who have neither interest in or aptitude for engineering concepts and higher order mathematics to learn the basic concepts needed in the essential areas of practical science, technology, and math in their daily lives. The added bonus is that the AMST model pushes the thought process farther into "who" and "how" the central problem-based scenario occurred and could even allow students to formulate recommendations on ways to ponder solutions.

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