STEMulate-K12: An Online Tool to Facilitate the Integration of STEM into K-12 Lesson Plans

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***Abstract* – STEMulate-K12 is an online STEM laboratory for K-12 learners, where experiments are simplified and reduced to just one or more bounded-parameters that students can control. Virtual labs enable students to interactively engage in any type of experiment without the typical limits of equipment cost and supervision. Its virtual experiments can pertain to any subject matter. The objective for STEMulate-K12 is to facilitate the integration of STEM into wide variety of lesson plans. This paper presents proof of concept.**

Keywords—STEM learning, engineering education, K-12

I. Problem Statement

Of the 50 million students enrolled in K-12 in the United States (U.S.), only about 4% go on to obtain a degree in STEM, and a much smaller fraction for underrepresented minorities (URMs) [1]. There is a strong need to increase K-12 children's familiarity and knowledge of STEM as either a career option or its importance to economic prosperity and quality of life. In 2010, Carnegie Corporation of New York funded a set of new science standards to help prepare K-12 children for STEM college and career readiness [2]. The new science standards with a focus of engineering are Next Generation Science Standards (NGSS). Research indicates that principals of engineering can support acquisition of knowledge and skills that are associated with comprehending and using STEM knowledge to solve real-life problems through design, troubleshooting and analysis activities [3]. Furthermore, NGSS supports engineering design as a foci or context for learning integrated STEM content, especially applied to real-world problem solving. With these reasons in mind, the researcher is developing an online tool that facilitates the integration of STEM into a variety of lesson plans and subject matter.

II. Introduction

STEMulate-K12 will be an online tool that will facilitate the development of a community of K-12 students and instructors that share STEM-related activities, in the form of virtual laboratories. Due to its K12-friendly graphical user interface, students should be able to understand, control, and appreciate the world of STEM by being able to explore realistic experiments. A depiction of the tool being used during a history lecture about ancient Egypt is shown in Figure 1.

Young people are natural-explorers, often learning by trial and error. STEMulate-K12 leverages off this learning process by presenting explorative STEM environments as playgrounds. The tool is designed to support situated cognition as described by Brown, Collins, & Duguid, where concepts are best learned when they are situated and consistently developed through activity [4]. As research suggests, the tool is designed to scaffold learners across a range of domains [5]. The scaffolding is achieved by communicating problem solving processes, coaching users with hints and reminders, and facilitating a library for users to access examples of prior problem solutions.

III. Method of Use

STEMulate-K12 is expected to have a growing library of virtual environments for young STEM explorers. Education researchers and K-12 instructors will be able to contribute to this library. To contribute a STEM lesson to the community, an instructor will enter the specifications and upload images online. Specifications include preferred grade level, subject matter, text description of the STEM lesson, image or video link, bounded parameters that will be used to explore the lesson, and underlying equations. See Figure 2a.

As library content increases, most instructors will select a STEM lesson from the library instead of creating a new lesson. Choosing a lesson is a simple process. Based on the subject matter of the planned lesson, an instructor navigates to related STEM lessons through a pull-down menu to review one of several ranked choices (Figure 2b).

During lecture, the instructor will be able to interactively engage students by integrating STEM into the lesson. For example, assuming a portion of the lecture is about the Great Pyramid, the students can be presented with the problem faced by the Egyptians: For a particular pyramid size, how many blocks and how long will it take to complete the pyramid.

Figure 1: Illustration of integrating a STEM lab with a History lesson on acient Egypt.

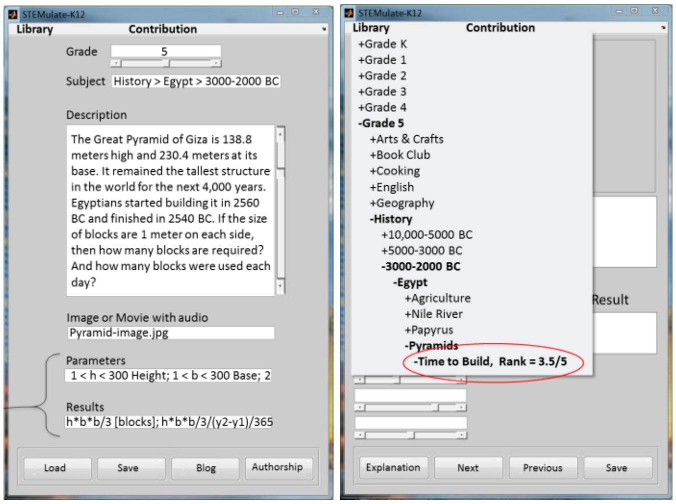

Figure 2: (a) Entry form for uploading new STEM lessons.
(b) How STEM lessons are organzied and selected from the tool's library.

An illustration of STEM lessons are shown in Figures 3a and 3b. The lesson includes an image or video of the laboratory environment together a text description of the problem that students must consider and solve. In Figure 3a the STEM environment is the 2500BC planning and building of the grate pyramid, and in Figure 3b the STEM environment is crop development on Mars. Although the mathematical relationship between the height, base, and volume would be beyond the educational level of the young learners, the bounded sliders in the tool's interface enables the students to play around with the independent parameters to investigate how the results depend on the parameters. This is not much different than how experimentation is done in cutting-edge research, where analysist test the sensitivities of each control parameter on the result to develop a predictive models.

Our hypothesis is that continued use of STEMulate-K12 will increase the interest in students in wanting to go further in STEM education to better understand why the mathematical relationship work and how they can be used to design new technologies.

IV. Discussion

This online application will enable users to better understand and appreciate the world of STEM by allowing them to explore problem solving using the basic engineering design process of identifying the problem, brainstorming solutions, planning a solution, testing a solution, recording results, and improving the solution. The tool will allow learners to manipulate problem solving method parameters of virtual STEM related problems. Such problems will be of scientific nature to include virtual problems representation of academic disciplines including humanities, social sciences, natural sciences, formal sciences, computer sciences, an array of professions, and applications to various cultures. A key aspect of this research contributes to the gap in knowledge of cognitive on-line learning tools that facilitate STEM cogitation, using real world problems, to create situated learning through realistic learning activities for persons in K-12. A future direction will examine how use of the tool increases STEM cognition in K-12 learners. A mixed methods study will likely be used to examine qualitative and quantitative measures. Qualitative measure will probe user interactive experiences with the tool's functionality such as the sliders used to manipulate experimental parameters. Quantitative measures will examine the rate of progression users achieve content knowledge.

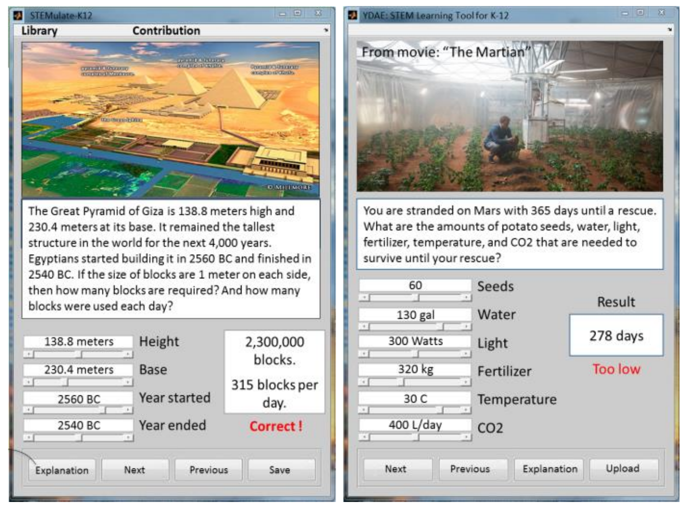

Figure 3: (a) Engineering lesson on building the great pyramid.
(b) Agricultural lesson on growing potatoes on Mars.

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