Teaching by Design: An Early Introduction to Science, Technology, Engineering and Mathematics (STEM) Concepts

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In 1960s, Seymour Papert and his colleagues at the Massachusetts Institute of Technology (MIT) designed a child friendly way of teaching computer programming concepts to young children. The development of Logo programming enabled young children to construct knowledge in a discovery oriented environment. Children could see their programming results downloaded into what was known as a floor turtle. The floor turtle was a simple robot attached to cord much like a computer mouse is attached, it could be programmed to obey simple logo commands such as move forward, backward, left, and right. Later, the personal computer led the floor turtle being modeled graphically on a small screen.

However, it wasn't until recently that the cost of computer technology became attainable to public schools. Additionally, computer technology has reached a level of graphic sophistication that can be understood by scientists and lay people, alike. Having these two barriers removed we are now at the stage that even children in elementary grades can benefit from interactive learning with computers. Seymour Papert states "I have seen hundreds of elementary school children learn very easily to program, and evidence is accumulating to indicate that much younger could do so as well."

Throughout history educators have attempted to develop instructional material to influence student learning with minimal success. Learning Science, Technology, Engineering and Mathematics (STEM) through lectures does not motivate students to learn the content and discourages students from pursuing STEM careers. These areas are best taught through hands-on interactive modules. Teaching by design enables students to work in a collaborative research oriented environment where they are provided with opportunities to think like inventors. Resnick and Ocko suggest "design activities have the greatest educational value when students are given the freedom to create things that are meaningful to themselves (or others around them). In such situations, students approach their work with a sense of caring and interest that is missing in most school activities. As a result, students are more likely to explore, and to make deep 'connections' with, the mathematical and scientific concepts that underlie the activities."

In this paper we present the development of a six-week unit on computer programming and robotics to be used with fifth grade students. The project is twofold. The programming component of this project covers decision-making and robot control through a graphic user interface, the graphic user interface removes the complexity of learning programming syntax which tends to distract students' attention from learning the actual content. A series of game-like graphic simulations of a robot will be used to teach the students basic programming concepts such as: variables, repetition, decision-making, and concurrency. After mastering programming, a series of robotic competitions lesson plans are developed to teach problem solving and engineering skills.

We follow a hands-on teaching method known as teaching by design. This method allows students to see the application side of learning while at the same time learning the theory behind the application. Thus creating a scientific community of learners, an "Inventors' Workshop." The ultimate goal of this method is to not only teach theory through application, but also to teach critical thinking and problem solving skills that will open up new avenues of learning for the students.