AC 2011-732: INTEGRATING NASA SCIENCE AND ENGINEERING: USING AN INNOVATIVE SOFTWARE CURRICULUM DELIVERY TOOL TO CREATE A NASA-BASED CURRICULUM

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Integrating NASA Science and Engineering: Using an Innovative Software Curriculum Delivery Tool to Create a NASA-Based Curriculum

During the spring of 2010, a team at Tufts University collaborated with a team from the McAuliffe Center at Framingham State University to create, test and train teachers on a NASA-based curriculum, “Living in Space”. The curriculum was designed to integrate NASA science and engineering through the use of LEGO Robotics and a new, interactive curriculum delivery tool called RoboBooks developed at Tufts University.

In this curriculum unit, students work in groups on an iterative, design-based challenge of creating a device to explore an unfamiliar planet for its potential to support life. The RoboBooks help scaffold lessons in which students engage in designing and programming a LEGO rover to traverse unfamiliar terrain, collect physical samples and collect sensor data. Students progress through the unit using RoboBooks, which provides students with programming support, technical support and instruction empowering them to work at their own pace. This support alleviates some of the load on the teacher to address technical or troubleshooting issues freeing him/her up to focus on teaching and learning.

The interactive environment of the curriculum tool integrates text, graphs, tables, pictures, movies, and LEGO MINDSTORMS programming that can be used to design lessons that scaffold engineering design challenges and investigations (see Figures 1-4). Students link the virtual (computer) world with the physical world (robotics creations) in the curriculum environment allowing them to collect all their data, ideas, reflections, and artifacts (through pictures and video) into one place. In this curriculum environment, students interact with and use multiple forms of representations to accomplish the design task.

This poster will discuss the teams’ experience in the process of developing a curriculum unit that integrates NASA science and engineering through the scaffolding that RoboBooks affords. We will share insights and feedback from our testing with over forty teachers and more than 120 students. We will close with a discussion on the potential benefits of integrating NASA science and engineering through RoboBooks and future directions.

Introduction

The purpose of this poster is to display the work of a team at the Tufts University to integrate NASA science and engineering though an interactive software curricular tool called RoboBooks. The RoboBooks tool is thought to help scaffold the content and to relieve the teacher of the responsibility of teaching programming skills on top of their responsibility of teaching the science and engineering content. The integration of science and engineering into a design-based project is thought to help motivate students. This curriculum was implemented in workshops over the summer of 2010 and then tested in the classroom in the fall of 2010.

A challenge in implementing hands-on engineering design-based lessons in the classroom is that students often move at their own pace through the activity, leaving the teacher to have to coordinate multiple teaching tasks at once, such as responding to different student issues and keeping the class on task. This active learning environment can be a positive learning environment for students, but can leave the teacher overwhelmed.

RoboBooks addresses this problem by allowing a student or group of students to progress through an activity at their own pace. This tool gives multimedia delivery of information; important engineering and science concepts are presented in the form of pictures, words and video. This tool also allows for user input in the form of pictures and words (see Figure 4). Not only can students take in information and write or draw their ideas, but they can program LEGO NXTs right in their virtual workbooks allowing them to contain all information for their project in their RoboBook.

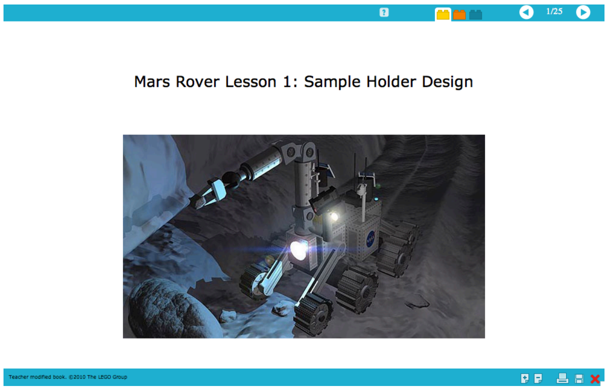

Figure 1: Introduction to the lesson.

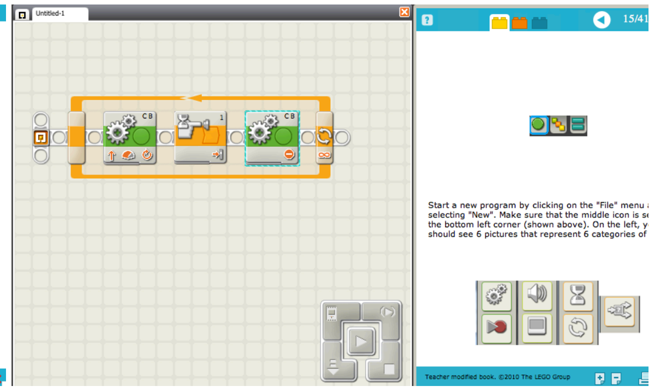

Figure 2: Integration of the programming environment (left) with the curriculum delivery environment (right).

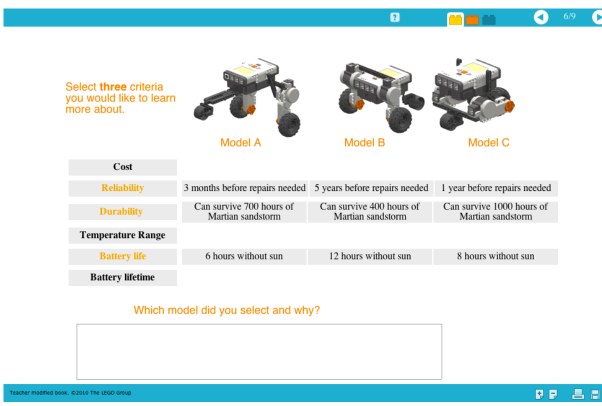

Figure 3: Example of embedding javascript element into the RoboBook environment. Here students select 3 criteria of the rover they want to learn more about.

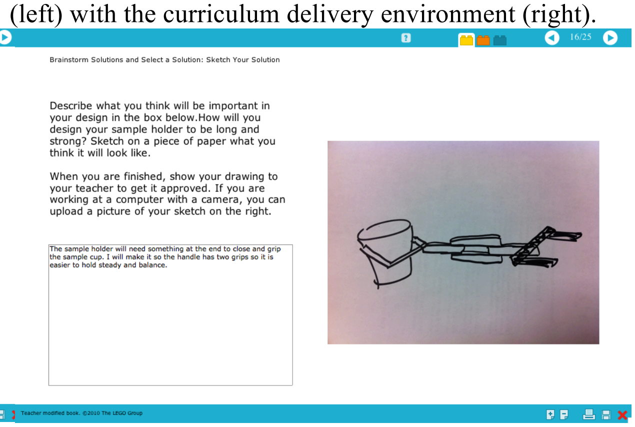

Figure 4: Example of collecting student input in the forms of text (bottom left) and sketches or images (right).

Since students are given the information through the RoboBook, the teacher is freed up to be able to help individual students. Rather than having to teach programming to the entire class, the programming concepts are presented in the RoboBook and the students are able to learn programming right at their computer.

Theoretical Background

The idea of scaffolding a persons learning comes from the Vygostkian idea of the zone of proximal development[1]. At the upper bound of this zone is a person's potential for what they can achieve through mediated activity, and at the lower bound is what a person can do all on their own[1]. Vygotsky viewed this mediator as a person who could coach or teach a person through their zone of proximal development so that they develop new and higher, upper and lower bounds of their zone of proximal development[1]. In this sociocultural perspective, mediation is key to learning[1].

A primary, and increasingly important mediating system in our current society is technology. Scaffolding is the process of supporting a learner as they apply new knowledge and ideas[2]. Scaffolded activity should include four elements. It should (1) illustrate connections between concepts, (2) give the opportunity to connect new knowledge to existing knowledge, (3) provide social supports for students to share ideas with their peers and (4) allow students to revisit their ideas[3]. RoboBooks provides the opportunity for addressing all of these elements; connections between concepts and connections to existing knowledge can be made evident through the multimedia presentation of content, and students have the opportunity to record their ideas through pictures and writing directly in the software, which allows them to both share their ideas with their peers and lets them revisit their ideas at a later time.

Scardamalia notes that small group work in classrooms can be fruitful; it breaks the pattern of the teacher relaying authoritative information to large groups of students, and lets the students' ideas become a greater part of the classroom discourse[4]. However, group work is also thought to have several challenges, including group domination by one or two students, knowledge and ideas becoming lost when not recorded and less teaching guidance of each group in a productive direction[4]. Technology has been thought to be a productive way to promote collective cognitive responsibility, the idea that the class as a whole is responsible for keeping track of knowledge and ideas that the group uses and works with[4]. Providing students with a space that scaffolds learning and allows students to record their ideas without heavy supervision from the teacher are some of the benefits of RoboBooks.

Another issue in the classroom is student motivation. Often times students are just trying to complete the task given to them without much thought about what they are really doing[5]. When the motivation in doing a task is to complete it, learning can be limited[5]. Motivation should be built into activities that promote learning[5]. The question of how to engage students is important in developing curriculum[5]. Integrating science into the curriculum through design-based challenges has been found to be a productive way to build some scientific understanding and simultaneously motivate students[6]. Design-based activities are also motivating in that they provide real-world context for learning[7]. The rationale behind integrating NASA science and design-based engineering activities was to provide a motivating context for learning.

Brown, Collins & Duguid note that, "the activity in which knowledge is developed and deployed, it is now argued, is not separable from or ancillary to learning and cognition."[7] A better understanding of the benefits and disadvantages of technology as a method of curriculum development and the activity that is instigated through the use of technology as a method of knowledge deployment will be important for understanding how to best use technology in the classroom. This poster will explore the benefits noticed by classroom teachers and the lessons learned from the project.

Teacher Feedback

Several teachers, who used this software in their classroom in the fall of 2010, were asked to provide feedback. Overall the teachers gave positive feedback on the content and noted that the content was relevant and well connected to what their students were learning in other areas in science:

"We study astronomy, we study the movement of the sun… I like the connection, because when we're teaching topics sometimes it's like, isolated, with the [program] and my astronomer coming in and... I want them to see that the world is connected, it's not isolated."

Annother teacher noted that she was pleased that the curriculum tied into what she was expected to teach for state standardized tests for engineering:

"I think that it was perfect because in the fifth grade content one of the things that they're tested on in the MCAS is exactly what they did. You have to, sometimes they give you a bunch of items on a piece of paper, and you have to take those and build something with it, and they want you to tell them the steps. How would you would you build it. So it perfectly ties into the MCAS."

Teachers also noted that this curriculum was motivating for their students. One teacher noted:

"I find students who are not usually motivated…it just enriches and just, it's just excitement… and they love the hands-on."

One teacher noted that one beneficial aspect of RoboBooks was that students could progress through the activities at their own pace. She was pleased that the students felt successful even if they did not all reach the same level of accomplishment:

"By letting the students go at their own pace, and work through the program, I think they got more out of it. And yeah, some kids did get farther, but that would happen anyway. And they all got to the point where their rover worked. They all got to the point where they were able to use the sensors to make it move. And that was it. They all reached success, so that was exciting for them."

Lessons learned

There were several implementation issues with the program. One difficulty that was encountered once the curriculum was sent to the classroom was working with different computer systems. Each school had it's own computer system, which was not always compatible with the software. This is a problem that is difficult to overcome, but as technology becomes more accessible to schools, making software that is compatible to each schools system may become more feasible.

Another implementation issue that may be a challenge for widespread use of this tool is the cost associated with the materials used for these lessons. Ideally a classroom using this tool would have about one computer for ever two students so that students could work in groups of two at a computer. At this point, most schools only have a few computers for each classroom.

Future Considerations

The main frustration in using RoboBooks was the incompatibility of the software with many school computer systems. This difficulty could be overcome through further development of the software to be easy to install on multiple systems. This is a challenge encountered by many, especially in schools with older computer systems. As technology becomes more prevalent in schools, this challenge should be easier to overcome.

The cost associated with integrating technology into the classroom is another hurdle for widespread implementation of this tool. Many classrooms do not have more than a few computers for a class of twenty or more students. Although most schools have computer labs, these are not always available for use. As technology becomes more available at a lower cost to schools, this may become less of a challenge in integrating RoboBooks into the classroom.

A positive outcome we found with the use of RoboBooks was that it provides a scaffolded learning space for students, which relieves some of the pressure from the teacher in teaching an active hands-on activity in their classroom. The students are given the task right at the computer and move through it at their own pace, the teacher does not have to worry as much about leading the class, but has more time to help individual students.

One teacher noted that even though she is the language arts and social studies teacher, she felt comfortable in teaching engineering and science with the support of this software. The open-ended aspect of the design challenges gave her students the opportunity to come up with their own ideas and the students did not have to follow a prescribed path to get an answer. This relieved some of the pressure from the teacher to have all the answers:

"It was very exciting to see them because we all think in a different way. And maybe I wouldn't have gotten to where they got at the same way, or I would have designed it. It's nice to see them really with, there were directions, there were guides, but they could build it themselves, so it was their own ideas. And I think that a lot of times in the classroom, they mirror what they think you want, so, in this they had no idea what I wanted, so that's fabulous, because they were free to really let their creative juices flow."

Testing and development of this software should continue both through revisions of this current curriculum, which was well received by teachers, and of other engineering-based curriculum to give teachers more options for what they use the software for. It is possible that this interactive curriculum delivery tool could be fruitful in other content areas such as science or mathematics. If technical difficulties can be worked out and costs can be reduced this is a tool that could see widespread implementation.

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