Utilizing Technological Innovation to Improve the Problem-Solving Skills of Middle School Students – One Group of Educators’ Experiences with the Lego-Mindstorms® Robotics System

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A two-tiered teaching example is illustrated. In the first tier, teachers problem-solve with their peers. In the second tier, a camp is conducted for middle school students to solve the same problem with the teachers running the camp.

In the fall of 1998, members of the mathematics department and the Institute for Interactive Technologies of Bloomsburg University met to discuss a problem of mutual concern: student difficulty determining the best way to begin to solve a problem, even when a given problem is derived from applications of simple mathematical concepts. Students often voiced feelings of frustration and confusion when approaching a problem and when questioned, fully understanding the problem solving process. In an attempt to find a non-traditional method to encourage students to understand the importance of approaching problem solving as a process, the group applied for, and subsequently received, a grant from the Pennsylvania Department of Education. The grant was to support the creation of an innovative problem-solving course which would utilize a combination of logic, “hands on” experience, and a modicum of trial and error; all employed to help students identify the processes behind effectively solving problems. The course was carefully designed to target middle school students. Students interested in innovative technology and, more importantly, at a critical point in their development of their attitude and aptitude when it comes to problem solving skills were the target audience.

The group of Bloomsburg educators utilized the grant money to develop a course that could be taught to local middle school teachers. The key component of the course was the inclusion of a new product of the Lego Corporation called Mindstorms. The Mindstorm system is a programmable robotics kit that utilizes an interfaced computer program to enable students to design, construct and manipulate their own robotics. The idea was to introduce the system to middle school teachers, familiarize them with the system’s operations and benefits, and then to encourage them to utilize it in their own classrooms. To this end, the University used a substantial portion of the grant to purchase ten Mindstorms systems and then donated them to the Central Susquehanna Intermediate Unit for classroom teachers to borrow.

During the summer of 1999, a group of eight middle school teachers representing as many school districts enrolled in the resultant course entitled “Implementing Lego Mindstorms in the Middle School Classroom.” The course proved to be as innovative as the Mindstorms system. The first week (20 hours) of the course involved familiarizing the classroom teachers with the Mindstorms System. Teachers were given a multitude of demonstrations, asked to experiment with the product, and were given technical support when needed. The teachers were then brought together for a series of discussions concerning the educational value and practicality of the system. They discussed the benefits of using the product within the classroom and explored ways in which the product could be introduced into the curriculum. The course was also designed to explore various problem solving techniques as well as the examination of the question of why students become frustrated and confused when presented with exercises that involve solving mathematical problems. The course also discussed ways in which the Lego Mindstorms robotics system could foster a heightened level of enthusiasm among students, encouraging them to examine their own thought process as they approach problems. The course also examined the benefits of the system as it relates to cooperative learning and group problem solving. The course addressed ways in which the Lego Mindstorms robotics system could be most effectively implemented within the teachers’ classrooms. Finally, the course provided the teachers with an opportunity to implement the program with a test group of students.

The second week (30 hours) of the course involved inviting 40 gifted students in grades 6, 7, and 8 to attend a one-week camp on the operation of Lego Mindstorms. During the camp, the teachers enrolled in “Implementing Lego Mindstorms in the Classroom” taught the middle school students how to use the Mindstorm system. Students were placed in groups of four and each member was assigned a specific task. One student was a builder of the Lego Robot, another student programmed the robot, one student organized the Lego pieces and one student was the group’s journal keeper. Each task was rotated among all four group members so each could experience the various roles integral to the project. For example, on Monday Shannon was a programmer, on Tuesday she was a constructor, etc. The students began by building simple
robots with designs they received from an instruction manual. By the end of the camp, the students created their own Lego Robot and had a competition to see which group’s robot could push a golf ball across a floor for a given distance in the shortest amount of time.

The teachers convened in the third week to discuss how this system could be implemented into their school curriculum. The teachers made many observations and provided the University participants with valuable feedback. Some teachers expressed concerns that having four students within a problem-solving group left some students disengaged during the process. Teachers felt that three students would be ideal, believing that the role of the journal keeper could be eliminated. Teachers also agreed that the system could be more readily implemented in a classroom setting where the same students had the same robotics system each day for several weeks in a row. One teacher suggested that the robotics system could be installed in a school’s computer laboratory.

The Lego Mindstorm unit has proved itself an excellent teaching tool for many reasons. Primarily, the system teaches students problem solving skills because they are given the opportunity to design, develop and test their own robot. Students seem happy to “play” with the robot to get it to perform the functions they want it to perform. Students know immediately when they have made a mistake, for the computer program they created will not move the robot in the manner they were expecting. Such “failures” are a tremendous learning opportunity for the students. Because they generally perceive the reason for their “failure” as something they did or did not do, they can return to the program, examine it, and make changes they believe will solve the problem. Student groups can work through a number of problem solving steps before teacher intervention becomes necessary.

Students remain highly engaged throughout the process because they visualize their robot as a toy. The robot becomes much more than a toy, however, as students gradually learn how to control the robot and command it to perform specific tasks. Working within their problem-solving groups assists in the development of interpersonal, communication, and team-building skills. With every student an integral part of the team, students learn that constant, clear communication is a necessity. The development of these skills becomes valuable, as students will often encounter a problem they cannot solve on their own while building the robot or writing the program.

Finally, the techniques and strategies students utilize to fix their robots will help them when they encounter future problems. In working with the robotics system it is not always immediately clear why a program fails to make the robot perform a specific function. Students learn to check both the program itself and the construction of the actual robot, as a problem in either area can render a robot motionless. The students also discover that sometimes a robot that fails to perform as expected is a result of a combination of both the program and the robots construction.

The robotics system shows promise in not only helping students with direct, “hands-on” problem solving, but may hold some promise in helping students solve written problems as well. The robotics system teaches students that they must be able not only to identify why the robot is not functioning correctly, but that they must also be able to clearly articulate the problem to their fellow group members if the team is to solve the problem. The focus of many of the new tests of problem solving capabilities require students not only provide a solution, but to demonstrate the processes involved in determining the answer.

Although the new robotic invention product shows promise in the area of the development of problem solving skills, many questions have yet to be answered. The primary problem centers on cost and classroom implementation. The systems are fairly expensive; many school districts would simply find them cost-prohibitive. In addition, the very nature of this product requires a substantial commitment of time on the part of both students and teachers. Since most middle schools have not implemented some sort of “block scheduling,” valuable time with which students could problem solve might not only be difficult to find, but may constantly be interrupted. Would such interruptions lead students to be less inclined to solve complex errors that necessitate experimentation? Finally, what promise does this system hold for those students not enrolled in “gifted” courses, or those students who are not mathematically orientated? Would the system prove more or less useful to them? Perhaps as the robotics invention system grows more popular both at home and in school, these questions will be answered.

References


When I expressed disappointment at not having more details of the robots, Beth Mauch (the author) promised to describe actual problems solved by their trial students, and the robots they built in a future article, so stay tuned! – Editor