Team-Teaching Secondary STEM Courses

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Abstract

The transition from high school to college can be difficult for some individuals. Especially in for students from high needs areas or first generation college students. In some areas, manufacturing is a dominant economic activity that requires students be competent in the science, technology, engineering, mathematics (STEM) fields and typically requires a post-secondary education for some of the better paying positions. In an effort to assist students with this challenge and educate more students for the manufacturing work force, a partnership was formed to put a secondary STEM teacher and college faculty in the same classroom. The partnership allowed students to know the local post-secondary educational options related to STEM and to get comfortable with the campus while being introduced to computer integrated manufacturing (CIM) practices. This initial class had ten students that participated and this paper will explain the details of the class and the successes of this partnership.

Introduction

In southeastern Indiana, manufacturing is one of the dominant economic activities. About 30 percent of the overall workforce works directly for a manufacturing company. According to the Economic Opportunities through Education by 2015 (EcO15), this workforce is not sufficiently trained to meet the needs of the manufacturers. To meet these needs, community education leaders, industry, and academia have partnered together in order to assist the workforce and the future workforce meet these needs. Part of this partnership has been to assist all of the secondary schools within the southeastern region of Indiana offer Project Lead the Way (PLTW) courses. These classes are being used to assist the students in gaining a greater foundation in engineering and technology that is not typically offered through science and math courses. Another part of this partnership is to provide the students with a pathway (named the “Seamless Pathway”) through high school and college that leads directly into a manufacturing position. Part of this pathway includes having the local university faculty, team-teach with secondary teachers in these PLTW courses. Currently, the faculty has and is team-teaching the PLTW course entitled Computer Integrated Manufacturing (CIM) at the local high schools. The purpose of having college faculty team-teach these courses is to introduce the students to college faculty in order to make a smoother transition from high school to college and provide more expertise in the secondary classroom.

The transition from high school to college has been shown to be difficult for some individuals. In this region in southeaster Indiana at least one high school in half of the counties in southeastern Indiana has been considered a high needs school within the last few years and many of these students could be first generation college students. Only 15 percent of the employed workers in this region have a bachelor’s degree which is 11 percent points below the national average. Student-teacher relationships have been shown to have an effect on the outcomes of student learning and desires to follow a specific career path and having their teachers share their research experiences may help these students make that choice to pursue a post-secondary education in science, technology, engineering, and mathematics (STEM). With
this understanding, this program is being implemented to assist with potential first generation college students make this transition.

The specific activities for the CIM course include basic controls with vex programming (introduces the students to basic programming logic and open and closed loop control), robotic programming (type is not specified), machining introduction (feeds and speeds), and computer numerical control (CNC) programming (by hand and with computer aided manufacturing (CAM) software). The university faculty also introduced the students to programmable logic controllers (PLCs) as an additional activity outside the CIM curriculum. The university faculty involvement consists of visiting the high schools on a weekly basis to review class progress on secondary teacher assigned projects and assist the students with projects. When the high school lacks the necessary equipment for specific activities, the secondary students are invited to the local campus to learn about the equipment and perform the specific activities. Many secondary schools do not have the resources to purchase some of this equipment as is the case with the teamed school. This paper will cover the implementation of the course, discuss some of the challenges and outcomes of the course, and end with conclusions.

Implementation

Last year, the initial CIM team taught course with 10 students was used to test this concept. The school had the required software and some hardware that was used for other PLTW courses taught, but did not have CNC equipment, robots, or PLC programming equipment used in the course. The first part of the class was held on the secondary school’s campus and covered introductory material, introduction to controls, and basic programming. The middle of the course was held on the college campus where the students were introduced to robotic programming, CNC manufacturing, and PLC programming. The end of the course was held at the secondary school campus as the students finished a final project related to manufacturing. All of the students were offered the opportunity to take an introductory materials course at the college campus paid from scholarship funds. The class was held the second semester of the school year and was offered after typical school hours.

The first portion of the class was directed by the secondary school teacher. The students reviewed ideas learned in previous PLTW courses and were introduced to controls. The depth of the discussions revolved around the difference between open loop and closed loop control. The students were supplied with a vex robot that needed to be programmed to follow a line on a map and make decisions as information was obtained from sensors. The connection between different types of controllers was made, but the students really learned a lot about trouble shooting code. The students needed to write a program to follow the line using different types of loops. On many occasions the students would write loops for the vex robots to perform a specific object and provide no mechanism within the code to exit the loop. The college faculty pointed this error to them and reiterated the need to design flow charts and program the controller to follow the flow chart with exit strategies for the loops.

The second portion of the class was directed by the college faculty with some assistance from the secondary school teacher. The students learned about robots used in manufacturing, material removal processes (including feeds and speeds), CNC operation and code writing, CAM, and
introduced to PLC programming (which is not typically associated with the PLTW CIM course). The students were first introduced to the operations of a CNC lathe and mill. For this introductory course, educational table top versions were used. The students were taught the basic G code operations in order to reduce the diameter of different sections of a rod to specified values. The students learned codes for starting the spindle, controlling the speed of the spindle, and linear movements. The initial project required about 15 to 20 lines of code to complete the cutting operation. Once the students finished this project, they were introduced to the mill and using codes for circles. The students used a mill to etch a word into a flat surface of an acrylic plate. Depending on the length and complexity of the letters used, the project required between 40 to 200 lines of code to complete.

EdgeCAM was used to teach the students how to use 3D drawings for making parts. The students learned Inventor in previous PLTW courses and used this program to create a box with a lid. The complexity of the part was left to the students. Figure 1 shows the table top mill that was used for all the milling activity and a sample of one of the made boxes. Most students incorporated something extra into their design that made the milling a little more interesting. The picture on the right of Figure 1 shows a 3D structure that the student incorporated into the design.

Figure 1. Denford CNC table top mill and part made on the mill.

Robots were introduced after the students completed their CNC projects. Two Amatrol model 94-RCP-1-A robots were used to teach this portion of the course. Two projects were given to the students: 1) have the robot build a pyramid with blocks and 2) have the robots work together to perform a continuous handshaking operation. The first project did not require any type of feedback. The blocks are provided through a slide conveyor and the students program the robot to grab the blocks and place them in the appropriate location. The second project required “handshaking” between the two robots. The objective was to have one robot pick a block out of its conveyor and hand it to the second robot. The second robot places the block into the top of the first robot’s conveyor. The project required feedback between the robots and was used for demonstrations as the robots could be left in a continuous loop. Figure 2 shows the two robots performing this handshaking operation.
The last part of the course taught at the college campus was PLC programming. LogixPro software was used for this objective. This activity introduced the students to ladder logic operations. Figure 3 shows an example of one of the simulations performed by the students of a garage door opener that requires on and off operations for the motor. The simulation had fault simulations for the students when the door malfunctioned to provide a more realistic experience.

Figure 2. Two Amatrol model 94-RCP-1-A robots performing a handshaking operation.

Figure 3. LogixPro PLC software simulation used with CIM course.
The class ended with students working on a final project for a small local business. The secondary school teacher had approached small business in order to find projects for the students that were related to manufacturing. The students used what they had learned to design a system for helping the business with its manufacturing process. The students planned on making a prototype of the system, but lacked the time to complete the prototype.

Of the ten students in this course, four applied to take an introductory college course for credit taught by the college faculty assisting with the CIM course. Additional students wanted to take the course, but extra-circular activities impeded them from being able to participate. Three of the students were accepted and supplied with scholarships for covering tuition and books through donations from members of the partnership that created the Seamless Pathway. These students were placed in the class with traditional and nontraditional college students. The course was an introductory materials class with emphasis on plastics. The students were expected to participate in group projects and perform the work to the same level as the college students. Two of these students applied to continue their college education on the same campus and are currently enrolled as freshman this year.

Conclusion

This initial secondary course of combining a secondary school teacher with college faculty was a success. Twenty percent of the students are now freshman at the local college and obtained college credit for courses while finishing secondary school. The organization of the class needs to be determined by the instructors that are team teaching the course. For this example, the secondary school teacher was grading all of the students’ work, even the work performed on the college campus. Specific topics were left to the individual teacher or faculty to explain and both participants helped in answering student questions. This course also helped the students become acquainted with college faculty and this familiarization should help with difficulties that some students experience with the transition to college.

References