Session 2148

The Use of Self –Directed Laboratory Experimental Learning in the Undergraduate Curriculum

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Abstract

The need to provide instruction that is more "student centered" and challenging to the individual student in higher education has created the need for new paradigms of teaching Engineering Technology. To meet this challenge requires a new look at how we have traditionally delivered the laboratory experience for Engineering Technology at the bachelors level.

The following paper describes how Eastern Washington University has chosen to meet this challenge using a non-traditional paradigm of delivering the laboratory experience in the Robotics and Automation course. The new method of delivery uses self-directed and self-designed experiments by the student to enhance the learning experience. This new framework of course delivery challenges the student to design and implement an experiment that is unique to him/her. The student is much more engaged in higher order learning since he must first design, understand and then perform the experiment. This is in contrast to the traditional method of the student blindly doing the same pre-planned experiment as all the other students, often not understanding or caring why he/she was doing the experiment in the first place. The paper further relates the experience and lessons learned in using this new method of laboratory experimentation at the undergraduate level.

Introduction

The traditional way that undergraduate laboratory experiments are implemented does not provide instruction that is "student centered" and challenging to the individual student. The traditional method of delivery of these courses may not be the most efficient for student educational learning [2,3]. Students are typically instructed to perform pre-planned experiments that have been very carefully crafted to demonstrate a specific concept or theory. All students in the class perform the exact experiment, and often, the same experiment is used year after year. We wonder why the students find this boring and wish to spend as little time as possible in the

laboratory. If the experiment is performed in teams, the team often degenerates to one or two students having the "hands on" learning experience while the rest of the students on the team are just watching with very little learning going on. The entire team is often not required to be fully engaged to complete the experiment. The main goal for some students is to speed through the prescribed lesson and go on to other pursuits. There can be some question as to how much learning has really happen. Were the students fully engaged? It would appear that often they are not. Did they have to develop the experiment with a goal in mind? Again, they did only what they were told.
When we use the traditional laboratory experience, the goal of many students is often to "get it over with" and further to do it in less than the scheduled/ appointed laboratory time. Not only were they not actively involved in the discovery and higher order problem solving skills, they often can wait and see how one of the other teams is doing it and then go through the same motions. At the end of the day they often wonder why they had to do the experiment. Questions are often asked of the instructor such as, "What was the point of doing this Lab today". The answer given by the instructor is very carefully written down so that it can be parroted back to the instructor in the lab write up. With this experience the student finds out little about the entire experimentation process. Higher order learning steps such as problem development, experimental planning and implementation appear to be foreign to them, as indeed they are since they did not develop the experiment, its goals or the method. Further, the uses of active learning styles are needed to allow the students to apply theory to the process [1, 2, 3, and 7].

Eastern Washington University decided to try to improve the above process and develop a method to attempt to fully engage the students. During the first 7 weeks of laboratory experiments within a 10 week academic quarter in the Robotics and Automation course, students learn about some of the various types of robots using traditional methods of pre-planned activities, often with many of the short comings listed above. The fairly passive styles of traditional methods used for this course were similar to those that have been indicated as one of the causes of nationally higher than desired attrition rates in Engineering and Technology students [4]. The short comings of this traditional method provided an opportunity to develop and monitor a unique student based experience to see if the students would respond in a positive manner and become fully engaged in the experiment. Since we wished the student to become aware of and participate in the design of experiments, we decided to have the student develop the experiment. The student's interest level in performing the laboratory experiment was also something we wished to improve. We asked ourselves the following question. When are we most interested in doing a particular task? The answer is often when we are doing something we wish to do or have an interest in doing. So, we need to make the experiment interesting to the student. However, we are all individuals and our interests vary. The problem then became how do we develop experiments that are varied enough to interest all students taking the course [6, 8, 9, 10]. In addition, every professor wishes to have his/her students so involved that students do not become "clock watchers". Clock watchers are those students hoping and willing the time to move as fast as possible and release them from the task put before them. When students are not fully engaged in the laboratory process and become disinterested, they risk becoming "clock watchers". Looking at the challenges set forth, it appeared to be an overwhelming task of designing multiple numbers of experiments for students to choose from. But even this did not involve the students in designing the experiment. During the process of redesigning the laboratory curriculum we recalled that students are very resourceful when motivated and this

should be used as part of the answer. Further, the best motivation is self-motivation. In the end the answer was to let the students solve the problem.
Students are assigned teams at the first day of the class. They are instructed that each team member of a given team will be given the same grade as the other team members for each lab. The instructor explains that this is what happens in the "real world". I would not be given a "good job done" by the boss or promoted if the project was a failure. We must win together or lose together. They are told that all team members have different strengths and that they need to use each other's strengths, motivate each other and help each other in order to accomplish the task before them. This is the way it is in today's industrial autonomous design teams which are comprised of members from various departments in an attempt to use concurrent engineering and reduce the design process cycle time. The students are told that they will have two weeks to accomplish the experiment with the robot given to them and to demonstrate their project to the rest of the class. At this point the students usually will ask what are the instructions / experiments that they are to perform. They are told that the requirements from the instructor are the least they will ever receive. In fact, there is only one set of overall instructions and that will be common to all three rotations of different robots the students will use. The students will be given a simplified instruction manual for each of the three types of robots used. The student team is to devise a unique experiment that demonstrates the ability of that particular robot and that impresses the instructor. The student team will demonstrate and explain the experiment at the end of two weeks. The explanation must include a discussion of the strengths and weaknesses of the particular robot being used and a description of how the project chosen is suited to the robot. The choice/design of the end effectors used as well as any accessories used must also be addressed. The demonstration is required to be video taped so that future students can see what others before them have been able to accomplish. A ten to fifteen minute video is then shown of clips from previous years. This helps to set the level of expectation for the projects.

There are three rotations or types of robots used. The first is a kit type robot with seven servos. The current kit used is a ROBIX kit. This type of kit is used because of the ease of use and because the kits have the ability to create several different types of robots. The programming language is straight forward yet, allows for total control of the motor movement including acceleration, steady velocity and deceleration. With this kit the students can let their imaginations go within the limits of the kit. The motors have very little power, so, while they learn about how robots move, they will not hurt each other while learning the safety lessons. This will not be the case on the industrial robots used in the subsequent experiments. Because the kits are relatively inexpensive, we able to have one kit per two students. The second rotation of robotic projects makes use of (4) industrial ADEPT SCARA type robots. The ADEPT robots allow for larger payloads and more varied end effectors. The students are shown the end effectors available but are free to design and build their own. All fixtures that are needed are also fabricated by the students. The third type of robots are (2) FANUC Spherically Articulated Robots, (1) FANUC GMC Spherically Articulated Robot and (1) FANUC GMC Cylindrical Articulated Robot.

Student Project Photos

The best way to show how the students did with their very short (two week) lab assignments is to present a few photos of their projects. Additional photos as well as videos of sample student

projects can be viewed at the departmental robotics web site located at:
http://etmd.ewu.edu/robot_lab/robot%20page/index.htm

Figure 1
A Cylindrical Robot working with a SCARA Robot to simulate a machine loading and milling operation

Figure 2
Robix Robotic Kit used to insert a light bulb and then turn on a switch for testing.

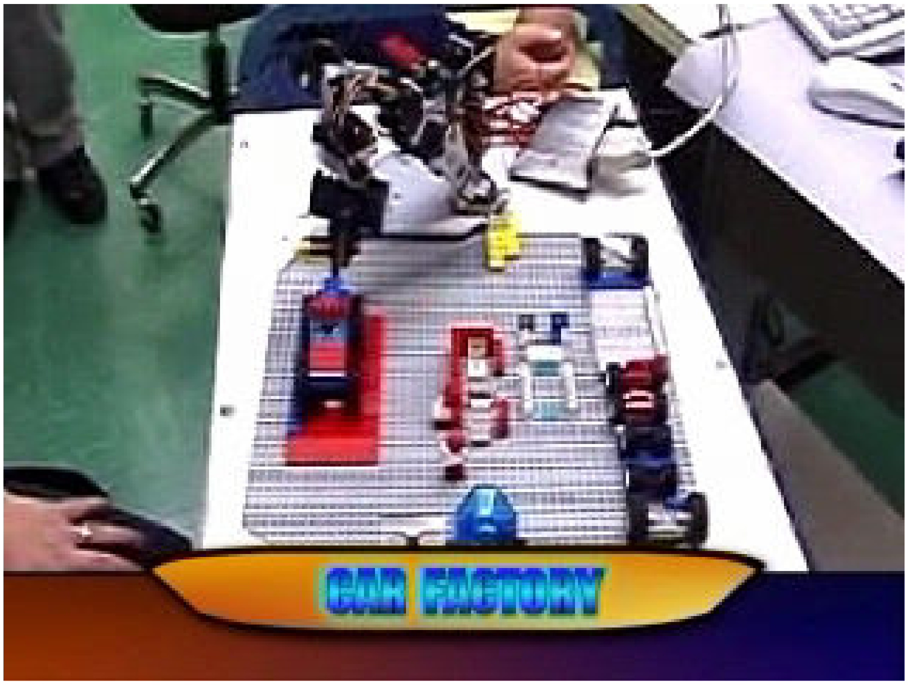

Figure 3
A Robix Robotic Kit used to assemble cars

Figure 4
A SCARA type Robot used to make hamburgers with a grill. The robot loads the hamburger on the grill and then takes the cooked hamburger and assembles the sandwich.

Figure 5
A Spherically Articulated robot used to wax a snowboard.

Figure 6
A SCARA type Robot used to assemble a jigsaw puzzle.

Lessons Learned

After using the new laboratory curriculum for three years, numerous lessons have been learned from studying the project demonstrations and student evaluations of the course.

Students really like the idea of designing their own projects. They spend time in their teams determining what they can do with the limitations and strengths of the particular type of robot with which they are currently working. The students often choose projects that have a greater difficulty and complexity then I would have assigned to them.

Students take real ownership of the project, demanding to be able to spend a lot more time in the Lab then the normal scheduled hours. The interest level has driven the Robotics Laboratory to be open and available to the students in the course at all times during the day. Different team members can be observed working in the lab throughout the day.

Teams that use proper team dynamic skills tend to be able to accomplish the more complicated projects. Teams divide the work among them and try to help each other out. The students self motivate each other and require that all team members are fully engaged and pulling their weight.

Often, the teams design projects that require new or different end effectors, feed or orientation accessories. The students will design and fabricate the needed items as part of their project. This willingness to go the extra mile to make a project work is a direct outcome of the fact that they are doing a project that they want to do.

Conclusions, Reflections and the Future

The student response to the self directed projects vs. preplanned experiments has exceeded all expectations we had hoped for the course revision.

Students are fully engaged and need to use higher order problem solving skills before they can design and demonstrate their project. The student must learn about the particular type of robot including its strengths and weaknesses, they must learn and understand how to program the robot using the language used by the robot controller. The student team then has to design a project to work with the robot taking into account what they have learned about the type of robot being used. They see, first hand, the problems with applying a robot to a specific task and what needs to be considered in designing a robotic work area. This includes the accessories and secondary equipment. Questions in lecture are thoughtful as the students often are trying to see how the concept under discussion applies to their project and are often seeking knowledge to improve their project.

The course helps retention because the students are applying the theory they have learned in a self selected project that holds their interest. Other students not enrolled in the class often come by to see what is being done. Hopefully, this will spark interest in some pursuing a major within engineering technology. The students like to be able to come in on their own schedule to work on the projects. The course has thus become “student centered” and fun for the students and the instructor. Using video clips of past projects really helps set the tone for the course. The students seem to take up the challenge to design a project that is more complicated or more “Cool” than the year before.

The instructor has been able to fulfill the role as mentor and help the students discover as they progress with their project. The sense of camaraderie and hope that develops is truly a joy to experience. Eastern Washington University plans to continue using this new paradigm of delivering the laboratory experience in the Robotics and Automation course and to search for other courses for application. Other colleges and universities are strongly encouraged to explore using this method in one of their courses and hopefully they will experience the positive results that Eastern has.

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