

AC 2007-1518: INFUSING AN INTERDISCIPLINARY AUTOMATION EXPERIENCE IN ENGINEERING TECHNOLOGY EDUCATION.

Donald Richter, Eastern Washington University

DONALD C. RICHTER obtained his B. Sc. in Aeronautical and Astronautical Engineering from The Ohio State University, M.S. and Ph.D. in Engineering from the University of Arkansas. He holds a Professional Engineer certification and worked as an Engineer and Engineering Manager in industry for 20 years before teaching. His interests include project management, robotics /automation and air pollution dispersion modeling.

Infusing an Interdisciplinary Automation Experience in Engineering Technology Education.

Abstract

This paper will address the advantages; experiences and lessons learned in infusing an interdisciplinary Robotic, Automation and Programmable Logic Controller (PLC) course into the B.S. Mechanical Engineering Technology, B.S. Computer Engineering Technology and B. S. Technology/Manufacturing curriculum. Industry today desperately needs skilled engineers and manufacturing professionals that can modernize and improve manufacturing processes and product designs for manufacturability to be able to compete in the “global economy” of today. Therefore automation skills need to be introduced to the student in all three of the above degree programs. The author’s describes how his industrial experience helped him shape an interdisciplinary course that challenges the student to be creative and build on the strengths of his/her fellow students in four degree fields. The student of today needs to be more “Job Ready” and not just “know the theory” if he/she is to compete for the jobs of tomorrow. This includes being able to work in interdisciplinary groups to accomplish project goals. The use of self directed laboratory experiences can keep the students engaged and active in learning the course objectives. The use of laboratory teams made up of the different degree programs more closely simulates the reality of autonomous interdisciplinary design teams in industry today.

The paper will relate how the course has become one that the students not only come willingly to formal lab hours, but insist on having expanded access to make their project come to life. Employers today are also looking for employees that can accomplish smaller automation projects without having to hire a consultant that leaves as soon as the start button is pushed. The paper will relate examples of industrial alliances and how students have stated that the experience in the classroom has translated to the student being more “Job Ready” and actually receiving job offers due to these laboratory experiences. Finally the paper will give the authors lessons learned and reflections for the future of the course to respond to a changing industrial landscape.

Introduction

Industry today desperately needs skilled engineers and manufacturing professionals that can modernize and improve manufacturing processes and product designs for manufacturability to be able to compete in the “global economy” of today. The student of today needs to be more “Job Ready” and not just “know the theory” if he/she is to compete for the jobs of tomorrow. This includes being able to work in interdisciplinary groups to accomplish project goals. Traditionally each discipline in engineering education has been taught in a “walled off” experience of students in only one particular discipline. Not only have we isolated the disciplines from each other but often the students from each other. The “you need to be able to do this on your own” attitude has been ingrained to a fault. True, students need to be able to master and solve problems in their course work on their own but, this has been carried to the exclusion of learning the value of team work. Further traditionally the student never works with members of a different discipline. There is little wonder then why the young engineer has difficulty

transitioning to the reality of today's global environment. Today's environment not only requires that he/she work with other members of their own discipline but also work in multidiscipline design teams that often include not only other engineering disciplines but members from other departments such as manufacturing. Therefore, we need to bring to the student this first experience into the classroom where he/she can learn and make those first mistakes in team dynamics without possible damage to his/her career in a company.^{1,2,3}

Course Description

Eastern Washington University's Engineering & Design Department has taken up this challenge and developed a course that challenges the student to not only to work in teams but in teams of more than one major. The course that fits best for this unique experience is EWU's Robotics and automation course. This course is a required course for the Mechanical Engineering Technology, Computer Engineering Technology, Manufacturing Technology and Electronic Technology degree majors. As such this course provides the perfect melting pot of degrees to work with. During the laboratory portion of this course the students are assigned teams to work on various problems. The first rotation uses twenty Robix robotic kits that each contain seven servo motors and allows the students to build and program a robot that is challenging and fun, but at the same time does not have the power to inflict injury. The students have their first learning experience with robots and how they move in a safe environment. The teams are formed of two to three students for this rotation. For the second rotation, the students are again but in teams to develop and perform an experiment but this time with a true industrial robot. Eastern uses eight industrial robots from Adpet and Fanuc for this rotation. The student teams are made up of five to six students. After the first rotation the students now are ready to step up to the power and complexity of the industrial robots. The final rotation uses twenty Allen Bradley programmable logic controllers (PLC's). The students as in the past are divided up into teams of two to three.

The course is very different from all the other laboratory classes that they have taken in the past. The traditional model of repeating the same experiment over and over again year after year has been largely replaced by self directed experimentation. For each of the robotic rotations the students are given a modified instruction booklet and then told to simply "impress the instructor". They are to develop an experiment of their own design that solves a problem for one of the local industrial partners or to create one that they feel is interesting and demonstrates the concepts of using robotics. The students not only have to program the robot but design and fabricate the end effectors, feed mechanisms and other work cell components required. This amount of work requires that the team work together to accomplish the project. The students determine who has the best skills to accomplish each subtask. In this way they learn to value each other's disciplines' skill and value as a team member. This again simulates what happens in many of today's autonomous design teams in industry. Where every members needs to depend and work with the other team members in a collaborative approach to meet the project goals.

The last rotation on PLC's is structured in a different form than the first and second robotic rotations. The problems are devised such that the student team must understand the process that is being automated. The process must be studied and then a automation solution is developed along with choosing the sensors, actuators and other devices to accomplish the task at hand. The process must then be flow charted. The number of inputs and output required are determined

and then the automation plan is worked out in words before the programming begins. The PLC's are then programmed using ladder logic programming. Again different skill sets are used to accomplish the tasks at hand. The team has to determine who has the best strengths to lead each step along the way to solving the problem. Some majors are better at understanding the process flow, others the design and selection of sensors and actuators. Then others are more skilled at doing the actual programming. All members of the team participate in each step but the lead changes depending on the skill needed. Doing this the students learn from each other and get an appreciation for the other majors in the team.

Industrial Relationships

The course described above is very suited to bringing industrial or real world problems into the classroom. The ability to do this allows the program to show relevance to the theory being taught. These industrial relationships are key in order to keep currency in an ever changing technical environment of today.⁴ The ability to bring relevant problems to the course will enable an institution to make the learning experience more meaningful to the students. This sense of keeping the learning experience more meaningful to the students is one of the major recommendations of the Committee of Engineering Education of the National Academy of Engineering.⁵ These industrial relationships are true alliances. There must be true benefits to both parties, both to the academic university and to the industrial partner. The true benefit to the academic program was stated by Liaw when he indicated that strong industry ties and industrial involvement brings breath, depth and continuity to the engineering educational experience.⁶ One of the benefits that industry receives is that a project or problem can be looked at by the student team without the industrial partner having to disrupt his production or assigning his valuable resources into looking at possible solutions. The student gains valuable experience and exposure to real world problems. This then is a great win-win situation for the student, university and the industrial partner. This is one great way to form a longer lasting relationship with an industrial partner since you do not have to ask for money. However support from the industrial partner is a natural out growth of their involvement with the program and should not be overlooked as one of the benefits to the institution.

One of the questions often asked is how does an institution get industry to bring in the right kind of problem for a course such as this. One of the best ways is to have an industrial advisory council made up of industrial partners. This council meets at least once per year and reviews the curriculum of the program to insure that the topics covered meet the needs of the regional industry and that current practices are being addressed. The council is a great place to ask for help in bringing real world industrial problems into the classroom. During these meetings a great relationship can be formed with the industrial partners and individual faculty members. Through the use of the industrial advisory council they get to know each other and feel comfortable in contacting each other. Another source of industrial problems is from student internships. Students in the course of their work often can see opportunities for automation. The company may not feel that they can spend money on these projects without some sort of proof of concept and of course the laboratory can be a great place to perform this proof of concept.

All of these projects are great prospects for undergraduate research. The solving of the industrial problem or the investigation of a proof of concept brings a wealth of opportunities in learning.

The student has to research the problem and develop possible solutions to be further looked into and then formulate action plans and develop experiments to either prove or disprove the feasibility of each proposed solution.

The Student Experience

The Student experience has been very robust on several levels. The concept of working in teams has allowed the students to develop skills in team dynamics. The opportunity to learn this soft skill is one of the greatest benefits of the course. The student has the ability to learn how to get what he/she needs to do their job when the team member they want the data from does not report to them. The student also learns the needs of other members of the team and to appreciate the fact that they also have needs from him/her to enable them to accomplish their part of the project. Both the project and the report are given a single grade for the team. Therefore, they learn that they can not succeed unless they all succeed. This is a valuable lesson. They also learn that being 80 % right means they are 20 % wrong and the project to work needs to be 100 % right. This lets them know there is no “curve” in the real world, it works or it does not. The students learn to value and understand the great synergy that can be formed by team members with different expertise working on particular project. They come to understand that everyone on the team has a role to play and has value. This will serve them well as they make that transition into their first job. They learn that they as an individual do not know it all and need the help and expertise of a diverse team to accomplish the project goals. The projects the students take on of their own choosing are far more complicated and require far more time than those of a traditional laboratory. The students however, not only look forward to working in the laboratory during the formal laboratory times but insist that they have access to the lab on off hours so that they can come and work on the project. They are engaged and interested. They are having fun and look like it. When was the last time you have seen that in your labs. The student has to put more thought and work into the project but does not see this as a negative because he/she is working on something they wish to work on and not repeating the same old labs as the last few years.

The following figures are from some of the past projects the students have done. Figure 1 shows a “proof of concept robotics” project that was done for one of the local industries. This project “mocked up” two punch presses with the die and punch from the company. The project demonstrated how a single robot could tend both machines. Representatives from the company viewed the demonstration and with modifications installed the project. Figure 2 shows a project that the students did to simulate a machine tending operation with a cylindrical robot tending an operation done by a SCARA type robot. Figure 3 is the simulation of a quality control station that inserts a bulb into a tester turns the light on and then takes the light and put it into a shipping box. Figure 4 demonstrated an assembly operation by assembling a toy car made out of Lego blocks. Figure 5 used a SCARA robot to load a grill with a hamburger, close the grill, wait till it was cooked, then took the hamburger out of the grill and on to a bun. Figure 6 shows spherically articulated robot to simulate waxing a snow board. Figure 7 demonstrates a SCARA robot putting together a jig saw puzzle using a vacuum gripper. These are but a few of the projects from the very industrial to the whimsical that engaged the students in active learning of their own choosing which required the cooperation and appreciation of each student’s major in the project for its completion.



Figure 1
Proof of Concept for loading two Punch Presses



Figure 2
A Cylindrical Robot working with a SCARA Robot to simulate a machine loading and milling operation



Figure 3
Robix Robotic Kit used to insert a light bulb and then turn on a switch for testing.

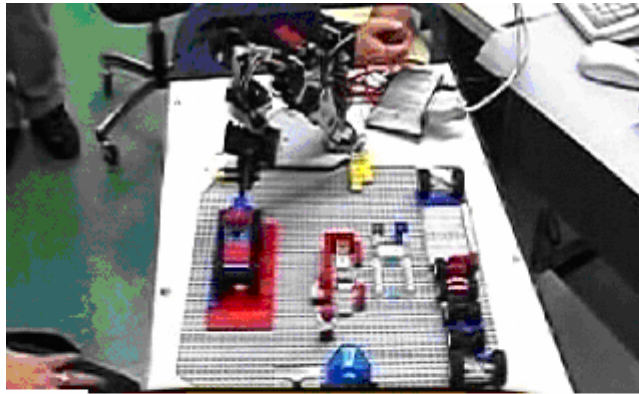


Figure 4
A Robix Robotic Kit used to assemble cars



Figure 5
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 6
A Spherically Articulated robot used to wax a snowboard.



Figure 7

A SCARA type Robot used to assemble a jigsaw puzzle.

Lessons learned and Reflections on the future.

Many lessons have been learned in implementing the course as described above. The students have learned to work well in teams. This includes the understanding what it means to work in a team environment. Some have faltered but this is the place to do this not on their first job. Students have learned to work well with other disciplines and become aware that all have important skill sets to contribute to the success of the project. Students have learned the value of disturbed work assignments within the team concept. Students have been able to work on undergraduate research projects for industry within the confines of the course. Students have become excited and engaged in the laboratory portion of the course. This has led them to want to pay more attention to the theory portion of the course as they can see how it relates to the work they are doing in the lab. Because of the laboratory experience some students have received internships and fulltime job offers that can be traced directly to their involvement in the course. Industry has been very receptive to the course and has been willing to help us find projects to bring into the class.

As with all projects there have been lessons learned for improvement and items to be particularly kept in mind for the future. Since team dynamics are a part of the experience the instructor has had to spend time in coaching the students and helping in solving problems as they arise. Since most projects are different, the time the instructor spends is more intense with each student since there is not just one lab project. Students are engaged and that is good, but it means the students expect to be able to ask questions on other than assigned lab hours. The type of projects the student choose needs to be monitored to make sure that they can succeed and have not chosen a project that is beyond their knowledge and time constraints. The instructor has found it useful to film each student team's project demonstrations. This serves two very important purposes. First purpose is to have a record of projects to show industry and students considering the major. Second the instructor uses the films to show on the first day of class to help students see the level of expectation and the type of projects students have performed in the past.

EWU intends to continue with this project and encourages other universities to look for courses that they can use interdisciplinary team projects to teach team dynamics that the student will be exposed to upon entering the new global work force of today.

Bibliography

1. Bosworth, K. and Hamilton, S. J., editors, "Collaborative Learning: Underlying Processes and Effective Techniques", New Directions for Teaching and Learning, No. 59, 1994.
2. Higley, K. A. and C. M. Marianno "Making Engineering Education Fun," Journal of Engineering Education Vol. 90, No.1, pp 105-107, January 2001.
3. Johnson, D.W. and Johnson, R.T., Learning Together and Alone: Cooperative, Competitive, and Individualistic Learning, Allyn and Bacon, 1994.
4. ASEE, The Green Report: Engineering Education for a Changing World, ASEE.org
5. Richter, D. and Donnerberg, J. "Utilizing Industrial Partnerships to Create Successful Grant Proposals", ASEE Annual Conference, Portland, Oregon, June 2005
6. Liaw, Benjamin, "The ECSEL'S Integrated Approach to Industry- Academe Relations", ASEE/IEEE Frontiers in Education 1995 Conference.