An Unexpected Experiment in Project Based Learning

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Abstract – In spring 2008, a group of students repeating Microprocessor Interfacing at North Carolina Agricultural and Technical State University and their instructor were forced into a Project Based Learning experiment without any prior knowledge of the concept.

Dealing with students that had already performed the lab experiments for the class, a lab that exceeded the maximum number of seats, limited supplies to perform experiments, no budget to purchase new lab materials and limited time to improvise a solution forced the students and instructor into this unexpected experiment in project based learning.

This paper will describe how the unexpected experiment came about, lessons learned, intangible benefits and pitfalls of project based learning.

Keywords: Teaching Methodologies, Project Based Learning

THE SETUP

Most educators have been placed in a similar situation. Students who are under-achievers fail a class and then ask to be placed in a class that is already at capacity. The simple word "yes" started a chain of events that eventually led to the project based learning experiment.

At the start of the semester, the five students repeated the same labs they had done the previous semester (with minor changes) and also attended lectures that covered the same topics. They attended and did their work but did not really engage in class discussions or go beyond their efforts of the previous semester. Albert Einstein once said the definition of insanity was "*doing the same thing over and over again and expecting different results*". About half way though the semester it was apparent that Einstein was right.

At about the same time another factor came into play. Like many technology programs, North Carolina Agricultural and Technical State University had limited resources. Labs were always at or above capacity and equipment and parts budgets, especially for the spring term, were small if not non-existent. There were a limited number of parts kits for the end of semester project (an ISA 8 Bit Parallel Input / Output Card), and no budget to buy more. Enough kits were available for the students who were taking the class for the first time, but not for the students repeating the class. Since repeating the labs had so far been ineffective, and with no budget to buy new kits, the idea of a special project came to mind.

After class one day, a meeting was held with the five students and the lack of parts for the end of semester project was discussed and they were asked if they would "help out" by agreeing to participate in a group project, thus freeing the parts for their fellow students who were taking the class for the first time. They agreed as long as they could pick the project.

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THE PROJECT

For many years, the instructor had been purchasing computer Input/Output cards, parts for robot projects and items that could be interfaced to microprocessors and microcontrollers that would be of interest to students. Reaching into this supply, the instructor came up with a list of possible projects that could be done with the parts he had on hand.

Five separate projects were presented to the students for them to choose from (although they were told that they could also choose bits and pieces from the ideas presented to come up with other project ideas on their own).

Out of the ideas given, the students chose to do a light following robot built using the parts listed in the table below:

PLC-730 32-channel Digital I/O Card (Advantech)
Compact L298 Motor Driver / H-bridge (Solarbotics)
Toy Tank Body (Radio-Shack)
2 x PbS Cells
MAX-158 8-bit Analog to Digital converter IC

Table 1 - Parts List

Since the rest of the class was building an ISA 8 Bit Input/Output card, and the PLC-730 I/O card used the same principles, the lectures were of use to the students doing the robot project. However many concepts they would need to complete their project were not included in the lectures. Because of time constraints during the scheduled lab time, the students were told that they would have to research these items on their own and make an appointment with the instructor when they needed assistance.

Breaking Old Habits

The first week in lab after assigning the project, the students set out to do their research. This phase went well since the group divided up the parts list and each member found information on their assigned component via the internet. But after the research phase their work stopped. It came to light that the students had never before been asked to design a system from components and they were overwhelmed. Only when the instructor asked for a status report was it discovered that they had stopped work and were waiting for the instructor to come to them and give them the answers to questions they were unable to articulate. A meeting was held and they were asked to bring their research. A discussion was started to guide them towards formulating the right questions to get the project moving forward, but it was an extremely lengthy process that the students resisted since they were used to being given answers instead of hypothesizing, testing and evaluating the results.

Back on Track

Once the students realized answers would not be given until they had formulated the right questions to ask, they got back on track. A routine developed that they would meet as a group and figure out what questions they needed to discuss with the instructor. A meeting was then set up and a discussion was held to guide them towards their own answers, when possible, or lecture on certain aspects of the project when information was not easily obtained or the concept was difficult to grasp.

Construction and Programming

With little time left in the semester, the project kicked into high gear and the students were extremely motivated to complete the project. They figured out how to interface the H-Bridge, the MAX-158 Analog to Digital converter, the

PLC-730, the tank body and a personal computer as well as how to write the ASM program required to complete the project successfully.

PROJECT BASED LEARNING

A month or so after the end of the semester, the instructor was catching up on magazines that had been neglected for way to long. Looking though the May 2006 IEEE Spectrum an article entitled “The Olin Experiment – Can a tiny new college reinvent engineering education?”[1] caught his eye. For those not familiar with the Franklin W. Olin College of Engineering, it is an experimental program started in 2002. As the article stated it is “perhaps the most ambitious experiment in engineering education in the past several decades. Olin’s aim is to flip over the traditional ‘theory first, practice latter’ model and make students plunge into hands-on engineering projects starting on day one.” [1] The idea is to put forth projects to students and then let them try to accomplish the task set forth. As Richard Miller, the Dean at Olin put it “when you get hired in a corporation, that’s the first thing that happens to you: they give you a challenge for which you’ve not had the prerequisites. So we do that here from day one.” [1]

The article also made reference to “Project Based Learning” or PBL. By definition “Project-based learning (PBL) provides complex tasks based on challenging questions or problems that involve the students' problem solving, decision making, investigative skills, and reflection that include teacher facilitation, but not direction. Project Based Learning is focused on questions that drive students to encounter the central concepts and principles of a subject hands-on.” [2]

The article and subsequent research was an epiphany. The students and instructor were participating in a project based learning experiment and, looking back on it many valuable lessons were learned.

THE BENEFITS OF PBL

During the unexpected experiment, a multitude of benefits were observed in the PBL methodology.

Motivation

As stated previously, there were some problems after the research phase when the students waited to be told what to do and how to do what was necessary to design the system to control the robot. The students felt that the instructor was not doing his job because he was not giving them the answers before they needed the information, so much so that one student went to the dean to complain. But after this rough start, an attitude of “will show him” developed amongst the five students. They had something to prove and this was a very powerful motivating factor.

But there was another motivation that might not have been so apparent to the students, but it was quite apparent to the instructor: when the students met with the instructor and asked questions, they genuinely wanted to KNOW the answers. As with the Olin Experiment, the students were receptive to new concepts and theories because they had an application already in mind for the knowledge they were trying to obtain. Unlike the standard “theory first, practice latter” approach where students sit in the classroom and ask to themselves, “Why do I need to learn this?” the PBL approach worked much better for these students and it was refreshing for the instructor to have students actively participating in their scholarly pursuits.

Confidence

Another unintended side effect was boosting the confidence of some team members. Two team members, both women, were very unsure of themselves at the start of the project. Many times they would very meekly give a suggestion during a brain storming session in our project meetings, but did not assert themselves. Many times a question was asked and the more assertive members of the group would yell out incorrect answers, but the correct answer would be said, in a quiet voice, and the answers were quickly dismissed by the rest of the team because of who said it. The first few times this occurred, the instructor would stop the group and say “you know she is right!” But it kept on happening, so the instructor started to let the group go on for a bit, then say “you know someone stated the correct answer a few minutes ago” but did not say whom. The more assertive members figured out quite quickly that when that was said, to turn to them and ask, “What did you say?” You can imagine what how they felt.

When the project started, their answers and ideas were dismissed, but by the end of the project their input and insight was sought by the rest of the group.

Accomplishment

Most students go into lab and do the required work, and if we are lucky, they actually try to analyze what data they recorded while doing the lab. But in the PBL experiment, the students were proud of what they accomplished. The reaction when the project came together and worked for the first time was amazing to witness. There were actually high-fiving each other, cell phone cameras were going, and they were congratulating each other like they just won the Super Bowl. To see students, especially students who were unable to successfully complete the course previously, was well worth the time and effort.

Simulating the Real World

The class room and lab methodology of old is very far removed from the working world our students will face after graduation. PBL allows students to get a feel for the project and goal oriented world, but in a less hostile environment. It teaches them how to form working relationships with peers and superiors (like the instructor) and how to formulate questions that are typical of a new employee given a project in industry for the first time.

PITFALLS IN PBL

There are a number of pitfalls in PBL that were experienced during the unexpected experiment.

The most prevalent is frustration. Students are used to the "learn than do" approach to learning where they attend a lecture, are explained everything in advance then are given a canned lab that says what to do, how to do it and what to record. PBL as described by Dr Miller previously is more like that first day on a real world job. Students can be easily overwhelmed, as were the students in the experiment and, if handled incorrectly by the instructor, could easily just give up. A good faculty advisor needs to keep a close eye on a PBL group to insure that the frustration does not become a defeatist attitude. During the experiment, one student got so frustrated that he complained to the dean about the faculty advisor after an intense session during which the students wanted to be given the answers, and the faculty member was out of ideas of how to guide the students to their own answers.

This leads to the second pitfall, group work. As educators, we know that working in groups is an important skill to master and even ABET acknowledges the need for group interaction in scholastic exercises. But group dynamics is very hard to manage. Will the students work well together? Will all the students participate, or will there be one person doing all the work while other receives credit for doing nothing? Surprisingly the students in the unexpected experiment were very forthcoming about the contributions, or lack there of, by other group members. When asked to grade each member of the group it was quite apparent who did and did not contribute. It was also interesting to note that each student downplayed their own roll, while giving credit to others on the team. It was also interesting that the highest rated team member was not the most technically proficient, or the students that spent the most time on the project, but the one who led the group to the successful outcome. It was probably lucky that the five students thrust into this experiment knew each other, worked well together and whose skills and personalities generally complimented the group, but it could have been much different indeed.

Grading is also very difficult in the PBL paradigm. Many educators have faced the issues of grading group work, and with PBL not every student gains the same knowledge from the project. Since there is no syllabus of topics covered, lectures with notes or one text used for the class, the issue is how to evaluate the students' performance and have it reflect the students' work, knowledge gained, participation and sweat equity. This can be handled by observation and asking impromptu questions of the students to see if they are participating and sharing what they have learned with the others in the group, but this takes time and must be quantified for grading purposes and is very time consuming.

With PBL, it is impossible to have a lesson plan or canned lectures. In the experiment, students would bring up totally unexpected topics so there were times that the instructor was caught off guard or did not have needed materials at hand to discuss a topic when asked. This can be unnerving to some educators, especially when the topic is outside their area of expertise. Educators can anticipate many questions but students can surprise you so learn to expect the unexpected.

PBL is very time intensive, and surprisingly not only for the students but for the faculty as well. When students are working on a project, and are highly motivated, they do not look at office hours or make appointments, they want you to drop everything and discuss the latest problem with them, and seeing that they are motivated makes a good educator want to stop everything and guide them over the current hurdle. Also, as stated above, the group must be observed so that a proper evaluation can be made of the group and individual performance.

DOES PBL WORK?

Being an unexpected experiment, the author did not collect any data on how PBL compared to the typical course deliver methods. Unfortunately a review of the literature on the subject of PBL in Engineering and Technology seems to lack this data as well. In the words of one author "With the engineering examples of [project-based] learning, the evaluations that have been undertaken have been almost entirely along the lines of student interviews or responses to open ended questions." [3] Only in the K-12 literature did data on achievement and learning surface. One study at Stanford University found that "students at the project-based schools did better than those at the more traditional school both on math problems requiring analytical or conceptual thought and on those considered rote, that is, those requiring memory of a rule or formula. Three times as many students at the project-based school received the top grade on the national examination in math." [4] Other data in the K-12 is equally as impressive. In Tennessee, participants in the Co-nect program "outperformed control schools by 26 percent" [4] over students who did not participate in this project-based and technology program. So for K-12 the answer to the question, "Does project based learning work?" is yes, but without supporting data, we cannot emphatically state that PBL is a successful approach in Technology and Engineering higher education. There is documentation, although anecdotal, that strongly suggests PBL does work.

CONCLUSION

This project based learning experiment in many ways confirms many of the preliminary results of the Olin experiment, but on a much smaller scale. Many of the issues faced during this unexpected experiment: frustration, the large time commitments, evaluation issues and team management were echoed in the Olin Experiment article, just as the benefits of confidence, accomplishment, pride and motivation.

Since no hard data was collected because the value of the exercise was not realized until months after its conclusion, it cannot be said that the experiment was a success, but the reaction of the students when the robot first worked as required will remain a strong motivation to continue using this technique in future classes.

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