Session 3250

Lessons Learned from Capstone Projects

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Introduction

Capstone or senior projects present students with an opportunity to learn from the experience of putting their technology lessons in to practice. This paper reviews some of the theories of learning from these experiential activities as well as provides some methods and examples for working with the students in these activities.

Picking the project

One of the foremost educational theorists, John Dewey defined several ways of thinking such as imagination, belief and stream of consciousness. He contended that learning happens through reflection on experience. [1]

Reflection is a meaning-making process, which moves the learner into a deeper understanding of experiences and links between the connections. The role of reflection is to make meaning, linking experience with knowledge. In other words, for Dewey, learning happens

when students reflect on an activity. Educators should promote both the activity and the reflection process.

Positive reflection is a community activity. Sharing the experience and the reflection process broadens the learning process by having other perspectives, assistance and support. Reflections require attitudes that value personal growth, for oneself and others. The context within which the experience, the participant and others create the dynamics within which learning takes place. Attitudes such as directness, responsibility, open-mindedness and readiness are necessary to make the reflective effective. [2]

Dewey goes on to give a list of criteria that an activity must have to have to be educationally relevant. [3]

1.   It must be continuous. Educational activities such as projects are not instantaneous, but they evolve over days, weeks or months. The project must cover a significant time span and the reflection on the project should note the progress of the project and the learning.

2.   It must be connected. Actions and thoughts must occur together for the most effective learning to take place. Acting without thinking is rarely useful and thinking too far ahead is usually only so much daydreaming. Additionally, educational activities must relate to each other. Good activities are not limited to one area but should span the human experience.

3.   It must be challenging. True learning is not always easy. We have to push ourselves to learn in a classroom. The same is true in fieldwork and reflection. We can all just work on a project, but the goal is to learn from the project and we have to work at learning, too.

4.	It must be contextual. Ask a young kid about what they learned from the fieldtrip to the zoo and they may tell you about the bus ride. Serendipitous learning is a wonderful sideline from project work, but reflection should focus on the zoo then the bus ride.

This becomes a good a criteria by which to evaluate the potential of a capstone project. If these criteria of a senior project are not obvious, the first task for obtaining approval of a project is for the student to describe how their proposed project meets these criteria. Success in the workplace for an industrial technologist requires a broad understanding of several areas. Some projects lend themselves more emphasis in one area than others but a good project will not be limited to one sub-discipline. Further, the discipline of Industrial Technology includes a combination of technical and managerial courses. The capstone project should include activities that cross over technical and managerial areas.

Student Reflection

So, if a project meets these criteria, how best can students learn from these experiences? Dewey [4] felt that reflection has steps similar to the scientific method. He outlines the following steps: suggestion, intellectualization, hypothesis, reasoning and testing.

This process requires the learner to be an active participant in the experience. This intellectual process of reflection is circular, with the learner questioning and testing which leads to more questions, much as the scientific method leads to more questions.

Kolb and Wolfe [5] theorized a more expanded model for learning during activities. It is described as a cycle, shown below. Starting with the experience (at the top) the learner reflects on the experience, which leads to conceptualization, or the placement of this new knowledge into his/her organization of ideas. The circle is complete when the learner tests the concept with a real life experiment.

Intertwined with this experiential cycle is the individual learning style of the student. Kolb identifies four: the converger, the diverger, the assimilator and the accommodator. Some authors use different labels for the different learning styles.[6] One part of the cycle will have a stronger impact than the others, depending on the learning style. That is to say that a student with a particular learning style will be more interested in specific aspects of the experiential activity. And as each learning style will be affected by different parts of the experience, so will they prefer different ways to display the knowledge learned.
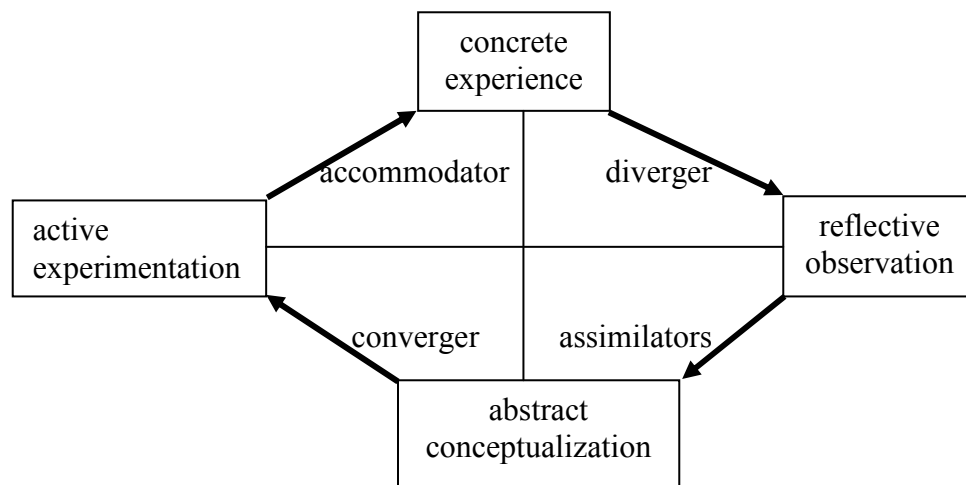

Figure 1. Experimental Learning Model with Individual Learning Styles (from Kolb and Wolfe, 1984)

Ideally, each student in each project would do the types of tasks that most facilitate their learning according to their individualized learning style. With dozens of students doing different projects, most of whom won't have a clue as to their individual learning style, it is not practical to individualize each evaluation beyond allowing some choice of assignments. There is no agreement or no clear-cut way of pairing the learning style with the best activity with any given experiential learning experience. There are too many variables to say that this activity is best for

this person in this situation. However, there are a wide variety of activities that can be used by students to get the most out of an experiential activity.[7] These include the following methods linked with the most appropriate learning style.

- Reading. The assimilators may find that ah-ha moment best by reading a case study similar to the event experienced. Examples: case studies, histories, textbooks.

- Doing. The accommodator may learn best with actions, which is obvious in many technical topics. Other examples include interviewing and role-playing.

- Telling. Like doing, telling works well for the accommodator. Examples include small or large group discussions or oral presentations.

- Writing. Writing is the most useful by providing the assimilators, convergers and divergers avenues for processing the experiences. Examples are journaling, letters, memos and papers.

Experiences and Techniques for Student Journaling

Of all the possibilities, writing will link the most learning styles with the project. Of these, journaling appears to the most universal way to make sure students are learning from their activities. It hits the most learning styles and it covers a span of time, as these independent projects do.

It requires diligence to help students develop successful journaling skills. Technology students are not generally renown for their writing skills, so journals must be checked regularly and comments must be given to improve these skills. Frequency of journal entries will vary with the project. During slow periods, weekly journal entries may be adequate. Daily entries should be expected during busy periods.

The students enrolled in capstone projects should be treated as adult learners. For some this will be their first self-directed project as they make the transition from student to adult worker. While several theories of adult learning have been presented, some common themes should be employed when managing a capstone project.[8] Collaboration, respect and praxis (combined reflection and action) should guide the interaction rather than intimidation or coercion. These students need to see value in assignments sooner rather than later.

Personal Example

One technique that has worked is to give students a pocket calendar (such as a give-away from a hardware store) to use as their journal. At the same time, provide them with a phone number or web address they might need during the next month. Then, attempt to steer them to use this reference and when they are at loss to find it, suggest they check their journal. This shows them that journaling includes items to for later use.

Students must be told what to expect in their journal. Each journal entry should have at a minimum, at least one technical item and one non-technical one. The technical entry might include notes about a phone call to a vendor and the non-technical entry might be if the vendor was nice or mean. If they can't find something non-technical to report on an entry, I recommend they write down what they ate for lunch. This is a trick used by service technicians who travel a lot. Records of meals can provide a back up method of re-constructing a days work if a journal is misplaced.

Another technique is to direct them to websites concerning journaling and the value of scientific notebook. A good example is the instruction page at the website Scientific Notebook Company[9] which provides instructions on keeping journals, including laboratory and engineering notebooks.

Student's Final Report

Journaling should not take the place of a final report, which could be written or oral. Capstone projects need final report which should include elements gleaned from the student journals. Possibly the greatest value of the journal is that it provides a timeline of the project and students often find the final report easier to write if they keep a good journal.

A report on the technical aspects of the project will be the easiest for the students to write. The students are given an outline to follow as best they can. (See Appendix A.)

It is valuable to require that students include an additional section, called Lessons Learned, which they should summarize the non-technical aspects of the project. (See Appendix B.)

Examples of Projects at CSUF

At CSUF, students have two choices of how to complete a senior project. The first is the more traditional approach where the individual student proposes a task to the instructor. The second is to join a project in a campus wide organization called the Solution Center. Here are a few example of how I have applied the above criteria.

In the traditional program, one student wanted to create a web-site. Certainly creating a personal web page is not adequately challenging or contextual. However he proposed to create a web site for a student organization that creates and sells laser engraved products. This could have still been a project limited to graphic communications except that the student organization was not entirely ready to provide the necessary information. The club did not have up-to-date product or price lists. Before he could create the web site, the student had to get his fellow students to agree on which products they wanted to promote and what the prices were. When he started the project, this information gap was called to his attention however he didn't believe would be difficult to overcome. In the Lessons Learned section of his report, it became clear that the managerial effort of setting prices was more challenging than the graphic communication.

Another student designed an experiment to test the corrosion resistance methods used in underground storage tanks. This experiment covered several subject areas from materials to electronics. The managerial efforts were limited to the management of material set up on irrigated farmland for a period of months. In the end, he analyzed his data and presented his results and a conclusion. At first he was confused about how a reflection would differ from a conclusion, but as the experiment progressed, he began to see that there were things that he did (or didn't do) that were valuable learning activities but might not be detailed in a strict scientific report. For example, he had a few false starts getting some electrical connections to withstand the irrigation sprinklers. A good deal of learning occurred during that time even though the scientific study didn't start until he overcome that hurtle. A reflection on the entire project provided a mechanism to describe these lessons learned which went beyond what was contained in the experiment's conclusion.

Besides these traditional projects, California State University, Fresno has established an organization called the Solution Center. When companies approach the university with small projects, the Solution Center puts together a team of students and advisors to do these projects. These projects include structured exercises in team building but can go in many directions. A list of clients and projects can be found at the university web site. Project guidelines and report templates can also be found at that site. [10]

Here are a few examples of these projects that have included Industrial Technology students. A database was installed to be accessible through out the plant at a large winemaker. Improvements were made to a paint bottling line at a craft manufacturer. A pump manufacturer had student evaluate alternatives for transporting material from warehouse to production line. Students conducted tests of adhesives to be used in join circuit boards to aluminum frames. All of these, and the other Solution Center projects that can be found on-line, included a group of students working under a faculty advisor.

For group projects such as these, journaling can be a very important activity. Such group projects may turn in unexpected directions through out the course of a semester. In one case, new regulations covering the area under study were published by a state agency. It was necessary for the group to stop the activities in progress and investigate these new regulations as they might impact their study. In the end, these regulations did not have much impact on the study. However those students who had kept good journals had a much easier time accounting for the weeks spent on these investigations with final report than those students who had been lax in their journaling.

Conclusion

Senior Projects can provide students a taste of what they will face upon graduation. Making sure the projects are continuous, connected, challenging and contextual is the first step and having a successful project. To get the most out of the experiential learning, activities such as reflection and journaling should be used. These provide a way of making sure that learning happens even if the projects include take intended or unintended directions.

Appendix A

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Technology at California State University, Fresno

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Appendix B

Assignment for Independent Study Students

At the end of your Independent Study/Senior Problem Report, include a section entitled:

Lessons Learned

In this section, please write a reflection on what you learned from the independent study. There are no limitations on what you can reflect on, except for the obvious such as being vulgar or slanderous. It is purely your opinion so don't write what you think I want to hear. Be honest and explain what you got out of the project. It should be <u>at least one page</u> long, but I expect you would write up to 4 pages without any trouble. It is like writing down what you tell your friend about the project.

- You could discuss the logistic roadblocks you encountered, how you overcame them and give suggestions for anyone repeating your study. (Example: "It was frustrating that I couldn't find a good source of battery acid for my experiment. I finally found one in the last month. I would suggest than anyone doing this test make finding the materials for this experiment a top priority and begin at the first week of classes.")

- You could discuss the people involved. (Example: Mr. Blank was hard to work with but Ms. Sheila was easy to work with.)

- You could even discuss things in the project. (Example: I was familiar with XYZ software which is different than ABC software that I used for this project and the learning curve was steep.)

If you are doing an internship or co-op project, you must keep a journal which you can submit that instead of a separate written reflection. A journal is like a diary, except you don't include who you kiss and what you think of Sheila. You must start this journal at the begin (or prior) to starting the internship. Contact me if you intend to substitute the journal for the reflection described above.

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