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THE USE OF REFLECTIVE STRATEGIES TO DEVELOP PROBLEM-SOLVING, READING AND WRITING SKILLS IN ELECTRO-MECHANICAL MANUFACTURING WORKSHOP

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Reflection follows action to allow for learning (Kolb, 1984). As the student reflects, the student can create questions, connect the task with prior knowledge, resolve a challenge faced, devise solutions, and so on. In a first-level computer engineering laboratory course (EMT 1130) at New York City College of Technology, CUNY, students answered three to five questions each week at the end of the class session. Two questions were more general, dealing with reflection and the task for the day. The other questions focused on the electronic and safety aspects of the class. As the semester progressed,students answered more questions related to electronics. The weekly questionnaires were analyzed and showed that students answered the task-based questions, but were hesitant in engaging with the reflective questions. These preliminary findings suggest that a reflection period be implemented in all engineering classes to help students develop their problem-solving, reading, and writing skills crucial to their future as engineers and technicians.

Background

The first-level computer engineering laboratory course (EMT 1130) at New York City College of Technology ("City Tech") incorporated a workshop in the 2013-2014 academic year, in which first semester students in the Computer Engineering Technology program build an electronic digital trainer. They use the "digital trainer," a box that contains rudimentary electronic components, in the next-level class, Digital Control (EMT 1250). The students begin by measuring, cutting, and bending sheet metal to the specifications in the manual. Following the sheet metal procedure, students input components; they will use these components later to test the functionality of the electronic trainer. After installing the components, the students begin to solder the wiring, connecting the components together. At the end of the semester, the box is tested for function by turning the various components on and off which light the seven LEDs (Light Emitting Diodes) on the box.

The EMT 1130 course, which meets once a week for 2.5 hours, isa prerequisitefor Electronics (EMT 1255) and Digital Control (EMT 1250). This series of introductory classes is where the students will learn about the components and the "how" of the box's operation. Although the Instruction Manual (in EMT 1130) does mention the components, it does not elaborateon how these components operate in the functioning of the box's inner circuitry. Students performed the tasks of building "the box" but did not seem to understand how the components worked to operate the box. What type of exercise would help students to focus more on the concepts of the electronic circuitry while also learning about machine shop "etiquette" and safety concerns?

The beginning of the use of reflection

The EMT 1130 course was part of a pilot program in the 2013-2014 academic year that focused on reading techniques in this freshman-level course. Peer Leaders participated in the weekly laboratory class, helping students through example, modeling machine shop procedures and safety practices. While there was an Instruction Manual, students would refer to it only when they had to follow specific instructions. Students would complete a task, following the instructions, without considering why the step was necessary. As a Peer Leader I recognized that when I took this course I had performed in the same way. However, in taking more advanced classes, I realized that connecting the task with the concept would be helpful. One way to accomplish this was through a "quiet" period of reflection at the end of class. Although one does learn quite a lot using practical methods, I suggested that writing about it would supplement learning. If I could describe what I did during my task in words, I would understand the process better.

"Reflection is a way of thinking about learning and helping individual learners to understand what, how and why they learn" (Hinett, 2002). Hinett proposed methods of incorporating reflection in programs of higher learning. The methods she proposed were: Learning logs and reflective diaries, portfolios, personal development plans, action learning sets, and problem-based learning. The students will encounter problems that would require reflection. As students encounters problems, questions such as "why" and "how" will shape their solution.

During my second semester as a Peer Leader, the professor and I decided to implement a five-minute "quiet" reflection period in which students would be able to reflect on their task for the day and answer questions from the manual in the class.

By integrating reflective, technically specific, and safety questions students should become technically competent and also be able to communicate effectively about their environment and daily tasks. Jolly & Radcliffe (2000) note that engineering students need to be well-rounded professionals, able to communicate effectively with team members, observers, and facilitators. Avoiding reflection precludes the opportunity to learn the language of engineering and the chance to practice it. The act of transferring thoughts unto paper into words may lead to higher levels of abstraction and analysis.

Reflection Questions

At the end of each class session, we asked the students to answer two to five questions (see Appendix A for the exercises) pertaining to the task and Instruction Manual. Examples of process questions were:

- What was the task today? If there was a challenge, how did you overcome it? (Be specific about your task and use full sentences)
- What have you built/constructed/done that helps you in your tasks in this class? (Question was asked so students can relate prior knowledge to present)
- What can be the benefits of working together rather than working alone?

Sample questions that were technically-oriented questions included:

- What types of materials are found in a class A fire?
- What does the transformer do when the power plug is plugged into the outlet? Draw a schematic of a transformer.
- If someone appears to be electrically shocked near you, what should you do?

Students' answers

In a class of 22 students, only twelve participated in the reflection exercises, which were anonymous, voluntary and did not count towards their grade. We administered one set of exercises per session for five weeks, beginning at the middle of the semester. As the weeks progressed, I noticed the same students handing in the work with answers in detail. Some students asked, "Why do we need to complete this?" When the last reflection exercise was handed out, some students who had not participated expressed relief to know it was the last one.

Six of the twelve students answered the technically-specific questions correctly. Three students, out of the twelve, answered all questions in detail. It should be noted that students could use any aid they wished, including web references, a textbook, or their lab manual (where all the answers could be found).

Discussion

There were only three students who may have received a benefit from doing these exercises. The other nine may have received a partial benefit by only finishing a portion of the reflection questions. Students ignored the beneficial challenge of reflective practice provided by either not completing or only partially completing the exercises.

Reflective skills are an important asset that engineering students should develop beginning in freshman classes. These skills would help students to consistently interpret their work and to better their methods for the future (Jolly & Radcliffe, 2000). Reflexivity is an important factor in reflection: it is an ongoing process of reflection before, after, and during the action. It is a way for engineers to be constantly conscious of the decisions they make. They may develop the ability to anticipate future actions and respond to change more comfortably. Unfortunately, the students who did not wish to participate in the reflection exercises denied themselves the opportunity to understand abstract concepts and reflect on their mistakes.

Students saw the exercises as an addition to their workload. Since some students felt the exercises were a large burden for them, we allowed students to either finish them in class on session time or take them home to finish without the constraint of completing before the session's end. These questions were designed to be finished within ten minutes. There was a re-occurring problem with some of the students taking the assignments home, but then forgetting to bring the completed assignments back.

Students may be turned off to the need of developing a process for reflection because they are not accustomed to it. Learning to reflect can be seen as conflict to some students. It may be a foreign process for students to reflect. Davis et al. (2003b) implemented a "conflict" setting in a junior Software Engineering course. In regards to conflict, they had the students write in their journals for five minutes at the end of each session. They arranged groups in which each student chose a specific job to do within the group. Groups were completely in charge of their projects with faculty guiding if a conflict occurred. The groups also had to present their finalized projects. The intention was for the students to be uncomfortable. But the students had to learn to be uncomfortable to adapt to that feeling. Freshmen students should come to realize that conflict can be used in the process of learning.

Suggestions

Students may take the exercises more seriously if it can be modeled after a "real engineering" sheet (Jolly & Radcliffe, 2000). As incentive to complete the exercises, students may be rewarded with extra credit points. Extra credit could also be provided to a student who chooses to maintain a journal about their experience and shows reflective practice. A peer-oriented reflective exercise in which they ask their neighbor or partner these questions might be helpful. As a means of helping students understand their current task in light of engineering practice, guest speakers could be invited to speak or "lead" a workshop based on their experiences in industry and relating to reflective practice, which may help students relate to situations they will face in their chosen profession.

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Appendix A

First exercise

Q. 1. What have you built/constructed/done that helps you in your tasks in this class?

Q. 2. When you read the manual, what do you look at?

Q. 3. What was your task today? Was there a difficulty you faced?

Q. 4. If someone appears to get electrically shocked in close proximity what would you do?

Second Exercise

Q. 1. How can this reflective exercise develop your problem-solving skills?

Q. 2. What does the transformer do when the power plug is plugged into the outlet?

Q. 3. What is the schematic symbol for a transformer? (Use manual as reference)

Q. 4. What was your task today? If there was a challenge, how did you overcome it? (Be specific about task and use full sentences)

Third Exercise

Q. 1. What was your task today? If there was a difficulty, how did you overcome it?

Q. 2. What can be the benefits of working together rather than working alone?

Q. 3. Where there any topics or steps that were unclear coming to this point?

Q. 4. What type of materials are found in a class A fire? (Use manual as reference)

Fourth Exercise

Q. 1. If you had the opportunity to fix any part of the manual, what would it be and how would you word it so that future students would be able to understand word for word what you mean?

Fifth Exercise

Q. 1. Describe in detail what steps you have take to construct your digital trainer

Q. 2. Where do you find how to connect the ribbon cable wires for your digital trainer?

Q. 3. What would you do upon noticing a burning odor coming from your digital trainer after plugging it in to a wall outlet power source for testing?

Q. 4. Why should you wear protective goggles/safety glass at all times in the lab?

Q. 5. How and where do you go for help in any aspect of constructing an electronic device?