Promoting Critical Thinking Skills Through a Capstone Course

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Abstract

Students must be taught to think critically, communicate, and work together effectively. If students are to become disciplined thinkers, they need to do a good deal of active thinking to take ownership of the content they are learning. Learning to think well requires many opportunities for practice in thinking through problems and issues, and applying concepts to real life experiences. This paper provides some critical thinking techniques and suggests that in a capstone course using the multi-stage approach encourages students to think more critically.

Introduction

For engineering technology students to be successful in their careers they must have necessary knowledge as well as critical thinking skills. These skills are sharpened to a degree during the college years through various activities such as lectures, assignments, laboratory assignments, and effective grading techniques. However, critical thinking is the art of analyzing and evaluating thinking with a view of improving it. Faculty members who tried to incorporate critical thinking as part of their instructions are convinced that critical thinking provides a greater challenge that encourages students to work more critically and creatively[1].

Industry wants students from engineering and engineering technology programs to be proficient in problem solving skills. While problem solving provides a key element in engineering training, students need to be taught how to approach the concept of problem solving. The concept of problem solving can be supported if the approach to problem solving is centered on the pedagogy of Critical Thinking.

In the book "Design Tools for Engineering Teams"[2], the following is given for problem-solving steps:
A team must share a common thought process for effectively finding solutions to problems. While there are many methods for solving problems, they all share four key principles:
- The problem must be clearly defined so people know what problem is being solved and what the successful solution of the problem will look like.
- Merely "solving" symptoms must be avoided; everyone must focus on identifying and eliminating the underlying causes of the problems.
- The chosen solutions must eliminate the problem and not cause additional problems in the future or in other places in the organization.
- Once fixed, problems must stay fixed. The organization must track and measure solutions to problems.

To teach team work and improve learning the idea of small group activities has already been implemented in the engineering and engineering technology laboratory assignments. A few institutions also have created learning communities to create an environment where students have an opportunity to register in a cluster of classes during a given term. This idea is a pre-designed instructional system that leads to instructional restructuring of students' time, credit, and learning experiences to build communities and to foster more explicit connections among students, among students and their teachers, and among disciplines. The goals of learning communities are:

- Promote engaged student learning and academic success
- Provide additional social and academic support
- Help students find their place in the university community
- Provide a setting for cooperative and collaborative pedagogy
- Foster a sense of community as a setting for learning

Critical Thinking
According to Dr. Richard Paul[3] a well-cultivated critical thinker:

- raises vital questions and problems, formulating them clearly and precisely,
- gathers and assesses relevant information, using abstract ideas to interpret it effectively,
- comes to well-reasoned conclusions and solutions, testing them against relevant criteria and standards,
- thinks open-mindedly within alternative systems of thought, recognizing and assessing as need be, their assumptions, implications, and practical consequences, and
- communicates effectively with others in figuring out solutions to complex problems.

Also according to Paul, educators need to engage students in various reasoning abilities[4] such as:

- Evaluating evidence
- Comparing analogous situations
- Refining generalizations and avoiding oversimplifications
- Analyzing issues, problems or beliefs
- Clarifying values and standards
- Questioning deeply
- Analyzing actions
- Exploring significant similarities and differences
- Developing one's perspective
- Exploring and evaluating solutions
- Analyzing and evaluating arguments, interpretations or beliefs
- Synthesizing subject-matter insights and knowledge

The Capstone Course

The course enables students to: (1) complete two projects based on their field of interest, (2) prepare an effective written technical report, (3) plan and produce presentation materials which most effectively communicate the intended message for their technical oral presentation, and (4) apply concepts and practices of their field of experience to develop and effectively present their

projects to colleagues and faculty.

Evaluation Criteria
Instructional methods include class discussion, student selected semester projects, written technical reports, and oral presentations of student work. Evaluation is accomplished in three primary stages. In the first stage, students are required to select a project topic of choice in a technical area related to their respective course of study. Creativity and imaginative thought in selecting a topic of interest are encouraged and expected in this stage. After selecting a project topic, students must plan, design and produce a formal written proposal.

In the second and final stages of evaluation, students must complete written reports that fully describe the project as it developed and reached completion. Reports are evaluated differently in the progress and final stages than the proposal stage. However, the reports include information from the initial proposal, progress made or status of the project, time line for completion, and cost estimate or analysis. For each stage every student must give an oral presentation to the peers.

The Multi-Stage Approach
In the Capstone course the goal is to change the approach of designing a project. The new approach takes advantage of breaking the task of designing into a three-stage process and incorporates a step-by-step approach to complete the given design. When a student finishes with the last stage the design is complete. In the proposal stage, students are required to give a presentation of their designs and are asked to identify all of the components and their functions for the proposed design and overall characteristics of the project. Also, the availability of the components, the cost, estimated time required, and the technical knowledge of an individual student about the proposed project are discussed. In the progress stage, students will give a presentation about the status of their projects, technical problems, and troubleshooting approaches that they have chosen. At this time, every student must have a working circuit for his or her project. Students who have technical problems and must do troubleshooting are required to consult with the course instructor about the chosen approach for troubleshooting. In the final stage, a prototype of the proposed design must be produced in an appropriate case for marketing purposes.

Oral Presentation Evaluation
The Evaluation Matrix presented in this paper (see Table 1) will be used to evaluate oral presentations for the Capstone course. This form is used not only to rate students, but to provide examples of what should be avoided in presentations and examples of what constitutes a professional briefing. Students should become familiar with descriptive phrases in each category ranging from "unacceptable" to "excellent." The graduation from poor to excellent simply allows the instructor to assess the quality of presentations in a general overall manner in each category.

Students are evaluated based on five categories: appearance, narrative, visual aids, organization, and content. In the content category the quality of the topic should be at an acceptable level for graduates of the electronics engineering technology program. This is not to suggest that over complexity and excessive detail are desirable. Rather, the topic should be of sufficient depth and usefulness for graduating senior-level students. Content should take into consideration the eight elements of reasoning[3]:

1. Purpose of the thinking: the purpose needs to be clearly defined. Is it a realistic design for the level of your knowledge? Does it have a good application? Distinguish between this design and the existing designs.
2. Question at issue of the problem: state the question at issue clearly and precisely. Analyze your design by breaking it into sub-designs. Make sure each part is functional prior to synthesizing the whole design.
3. Assumptions: clearly identify your assumptions: time management, parts availability, funding.
4. Point of view: in the proposal stage, express your point of view, and be open to other students' suggestions. Strive to be fair-minded in viewing other suggestions.
5. Concepts: identify key concepts and explain them clearly.
6. Evidence: clearly identify your assumptions and determine whether they are practical.
7. Implications and consequences: in conclusion report all positive as well as negative consequences.
8. Interpretation and inferences: conclude and report the practical applications and the limitations of your project. Evaluate your own project and discuss if there is room for improvement.

Conclusion

There are many ways faculty can help students become better problem solvers and think critically. Designing the laboratory instructions to encourage students to become problem solvers, modifying teaching pedagogy and using effective grading techniques can be applied to promote and teach high-level critical skills in the classroom. This capstone course provides a means for student academic achievement. Requiring students to do multiple projects and using multi-stage method of presentation will enable students to: (1) learn from their mistakes, (2) start troubleshooting at the early stage of the design, and (3) understand the importance of time-management concept.

References

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Table 1. EVALUATION MATRIX
CAPSTONE ORAL PRESENTATION (50 points)

	Unacceptable	Fair	Average	Good	Excellent
Appearance	2	3	4	5	6
Narrative	6	7	8	9	10
Visual Aids	4	5	6	7	8
Organization	6	7	8	9	10
Content	7	9	11	13	16