Maximizing Student Learning Through Hands-on Activities in Engineering Technology.

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Abstract:
Program outcomes typically describe what the program's graduates will know and be able to demonstrate upon completion of their degree program. To a large extent, hands-on skills are what separate engineering from engineering technology. What the graduates can do defines the quality of the program and hence the quality of the college

In the wake of the recent economic crunch, a new challenge is evolving for engineering technology programs in some areas of the nation. It is becoming harder to obtain industrial internships for students in order to maintain engineering technology's reputation and philosophy as a profession where knowledge of mathematics, physical and social sciences, and engineering is applied to planning, design and implementation of products and processes. It is very apparent that measures have to be taken to ensure that student learning is active and embeds hands on applications. The ripple effect of this challenge is less quality education that may lead to graduate unemployability, low enrollment, and hence program deletion

This paper discusses how the implementation of industrial exercises as a component of a regular class laboratory experiments has benefited the industries involved as well as maximized students learning even in the absence of industrial internship. It also shows how industries can be encouraged or motivated to participate in academic endeavors in a non-financial way.

Introduction:
College students everywhere experience various forms of problems. These problems have been expressed in such areas as course work, teaching methodology, interaction patterns in the classrooms, and inadequacy of facilities and equipment. In addition to these problems are the most recent observed problems in the areas of communication skills, comprehension abilities and interpersonal relations. These problems combined, cause stress and subsequently poor scholastic achievement in most students who find it difficult to cope with such stress

According to Gunstone and White[4], studies in higher education have shown that students' difficulties in learning are illustrated by their inability to apply rules or concepts to novel problems. Students need to be able to develop the ability to discern problems before finding ways to solve them. This is a training that is highly invaluable in the working world where problems are not always readily defined and presented to people for solution. It is clear that a

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problem well-defined is a problem half-solved. The ability to discern problems can be as important as finding solutions to them.

The aim of education is to get students to develop:

- functioning knowledge that enhances academic integration,
- declarative knowledge that provides the knowledge base,
- procedural knowledge that defines the skills required for their professions,
- condition knowledge that equips them with context for using above developed knowledge to solve problems.

In order to acquire this integration to achieve this aim of education, educators must put aside or revise the traditional way of teaching and learning.

Faculty members are charged with the responsibility of helping students adjust and react comfortably to stresses created by problems both on and beyond campus environment. This can be achieved by making classroom environment and courses fun and at the same time challenging for students. In doing so, faculty must:

- Provide a safe environment in which creative behavior and risk-taking is valued
- Provide students divergent imagery
- Provide students with cognitive tools with which to learn critically and creatively
- Provide students with surviving tools that enable them to function beyond college environment.

Engineering Technology can be defined as the profession in which knowledge of mathematics and natural sciences gained by higher education, experience, and practice is used to create and enhance technologies that benefit humanity. Technologists use their knowledge of mathematics science and engineering to make or build consumer products, bridges, machines, and all other systems that people rely on. It will not be out of place to say that there is no other profession where creativity, divergent imagery, and cognitive tools are needed more than in Engineering Technology profession.

The 21st century and beyond signals an era of unprecedented breakthrough in technology, and constant change in many aspects of life. It is therefore imperative for educators to face the challenge of developing ways to create a better-trained workforce. According to Porter[2] there is need for a more creative workforce as a nation progresses in economic development. The most efficient way to accomplish this is the constant upgrading of human and knowledge resources.

Desired outcomes of education for post-secondary students should be redefined to include characteristics such as ability to think, reason and deal confidently with the future, and to seek process and apply knowledge; innovations, a spirit of continual improvement, a life-long habit of learning and an enterprising spirit of undertakings. Globalization and rapid technological innovations call for new competencies. This has brought about a revolutionary rather than an evolutionary change in academic environment around the world. With this change, faculty continues to face new challenges that include new forms of learning, new technologies for teaching and new requirements for graduate competency. As we continue to search for new and effective ways to address these challenges, we need to continually evaluate how the skills being imparted are really transferable to the workplace.

Reid[3] stated "following college, many graduates discover another change, industry is not like college. Industry offers more emphasis on team accomplishments, more ambiguous problem definitions, and significant amount of time spent in communication, both oral and written." He asserted that these skills are not only more necessary but become critical to the recent graduate's success. Illustrating how important these skills are, Tobias[5] reported that the ability to assume a leadership role, yet function within a team and to communicate effectively are some of the typical characteristics which recruiters rate higher when looking for new employees. Reid (2000) then asked, "How can we teach effective communication, problem solving, critical thinking and develop a work ethic in our students without turning our degrees into five or six year program?" It is imperative for every college or university to realize that the answer is not addition of classes that specifically address all these competences. We should be able to accomplish preparing our graduates for a career in industry if every professor will endeavor to incorporate these industry practices into their courses as they go along. As globalization and rapid technology innovations continue to rise, financial constraints continue to make it increasingly difficult for colleges and universities to provide all the resources needed cope or address these changes and impart the necessary competency.

One approach that is being used to address some of these problems is the Problem-based learning (PBL). Some researchers and faculty have claimed that PBL is the ultimate tool to impact real-life problem solution approach that will last a life-time to students. Among the reasons for PBL in the classroom is its emphasis on meaning, not facts; increased self direction, higher comprehension, better skill development, interpersonal skills and teamwork. However, PBL is not without its disadvantages. Among these disadvantages is the fact that it centers on specific problems, it is time-demanding, traditional assumption of students, professors act more as a facilitator than a disseminator of information, and generating the proper questions is the most critical aspect of PBL. Without problems that encompass both a large goal and specific objectives which students must find on their way to reaching the goal's solution, there is a good chance that important information will not be studied. Dolmans et al.[1] found in their study, correlating student directed study and faculty objectives, that students did not stay on track and many important objectives were omitted.

Motivation:

In our program, engineering technology students have to go through a course of industrial internship before they graduate, which they normally complete during the summer session. In the past couple of years, it has become difficult to find appropriate industrial projects for these students. It is therefore feared that if this continues, students may be spending more than the necessary number of years to graduate. But in order to keep the students on graduation track, other courses have been used as substitutes for this internship, and sometimes these substitutes did not fully address the knowledge intended for the internship. Due to the recent economic crisis in the nation, some industries are finding it difficult to spare extra funds to pay internists. Some when approached, the first question is; "are we required to pay the student?" So it was then decided to kill two birds with one stone. That is, give the students the industrial experience they need and save the companies some money. This approach has not being developed to eliminate internship, but to give the students hands-on practical experience required of a good technologist. The students still go through an internship when one is found before graduation but incase one is not found and a substitute is made with another course, and so the internship experience is not totally lost.

This paper presents a method for enhancing student learning by providing an internship experience without internship. The approach reconciled industry's need-it-now goals with course ideals. The course being used for this innovation is ***IET 326*** which deals with "Productivity Measurement and Improvement." The course outline is vertically integrated and partially inverted to allow the generic skills to be developed throughout the process.

In the course, it was required that students be able to practically improve productivity of operations, improve productivity of workers utilizing work analysis and methods improvement techniques, ergonomics principles, and organization behavior. It also included ability to measure tasks and set standards to be used throughout the plant for similar tasks.
The process learning objectives are for students to:

- Have well developed self and team management skills
- Have well developed time management skills
- Be able to transform classroom experience into real-life industrial experience
- Be able to work in a team to complete a significant project successfully
- Be able to plan and monitor the progress of a project
- Be able to make effective oral and written presentations

In order to achieve this, the lecture was complemented with several laboratory exercises. The exercise process was divided into phases. The first phase involved a set of exercises performed in the classroom; it prepared the students for what followed in the assigned plant. The second phase was a set of industrial exercises performed in real-life plant environment. Some of the exercises in second phase continue to build on experiences from phase one. In each of the exercises, the students were divided into groups. These groups are dynamic for the class exercises but remain static for the industrial exercises. The entire process is as follow.

Phase 1: Classroom Exercises

1. Operation Process

   This exercise was designed to orientate students to the art of developing an operation process chart and transforming that chart into a flow diagram. At the end of this exercise, students understood the steps required in developing an operation process sheet, and chart for both machined and assembled parts. They also understood the usefulness of these tools in time study.

   Students were presented with physical parts and they had to determine the operation processes of the part and arrange them in a sequence that would enhance effective and efficient production of the part.

2. Elemental Breakdown with Basic Time Study

   Time study is a work measurement technique to record the time and to rate the elements of a specific job, and to analyze the data so as to obtain the standard time necessary for carrying out the job at a defined level of performance. In this exercise, students developed elemental breakdown and time-studied a machine shop process that familiarized them with the basic time study techniques. Understanding of how to break a process down into elements, perform simple time study and determine standard time study is an important part of productivity improvement through time study. As Seneca puts it, “If a sailor does not know to which part he’s sailing, no wind is favorable.” If the students do not know how to break a task into its elements, the best time study tool will be useless, because, the way they determine the elements of the process ultimately affects the accuracy and effectiveness of their results.

3. Time Study with performance rating
   Rating is an important and perhaps the most controversial aspect of time study. Its accuracy depends upon the ability of the person who performs the rating and this ability can only be improved though practice. One of the methods used to improve the rating ability is learning from an experienced analyst. This exercise introduced and familiarized students with performance rating. Although there is no unique formula for performance rating except that which come with experience, this exercise gave students a better understanding of the techniques of performance rating and prepared them for the industrial phase of the process.

4. Assembly line balancing
   One important aspect of productivity improvement is making sure that work activities among workers are evenly distributed. This exercise was designed to introduce and acquaint students with assembly line balancing which is one of the important uses of time study. If students will be able to improve productivity with time study, they need to understand the importance of line balancing and its relationship to productivity improvement.

Phase 2: Industrial Exercises.

1. Preparation for time study:
   This exercise further enhanced the students understanding and appreciation of time study processes. It involved combining all the tools of time study into one process. This included breaking jobs into elements, performing a practice time study and rating performance. Students were given this opportunity because performance rating is so ambiguous that even an experienced analyst may not achieve an accurate time on the first study.

2. Productivity Improvement through time standard:
   In the exercise, students performed actual time study of the assigned process, analyzed the study, and listed all observed and perceived problems during the study. They were required to determine what course of actions to take to eliminate each of the observed and perceived problems. No formal design or implementation was required of the students at this stage

3. Productivity Improvement with Time study.
   This exercise concentrated explicitly on the use of only time study tools. It was designed to give students the opportunity to demonstrate skills acquired in previous exercises.

Exercise 2 was extended to involve students actually developing and implementing the methods that will eliminate or reduce problems previously sited.

4. Productivity Improvement Through workstation design and redesign.
   This exercise exposed students to the art of workstation design with the application of ergonomics. This section takes into consideration that most industrial work is repetitive with countable outputs and goals set by others (management). To effectively design a workplace that will address the needs of the workers and satisfy the goals, the students are required to:
   - Holistically consider all the variables, parameters and constraints that may have technical, social, environmental and cultural impact on their decisions.
   - List and understand all goals of the exercise as well as company goals.
   - Set goal priorities. They must be able to prioritize work and nonworking goals.
   - List and understand all the activities that lead to the goals.
   - Concentrate on reducing lower back pain and carpal tunnel syndrome as the operation was a stand only operation.

5. Putting all the tools together.
   Even though the students had to submit a weekly individual report as they went along, this final report that tied everything together was submitted and presented by each group. The objective of this exercise was to enhance students' written and oral communication skills by giving them the opportunity to sell themselves and their design. This involved combining all the industrial exercises as one end-of-term project paper that would be presented to the professor and the host company's representatives.

Conclusion:
The welfare of students is a top priority in any educational institution. It is imperative that professionals such as university professors take vital roles in the well-rounded development of students. It is implicit that a supportive classroom atmosphere be fostered and nurtured in order to maintain students' trust and confidence in the university and their professors. It is also very important that university and faculty take into consideration the future of the students beyond the university environment.

The approach of making industrial exercises a component of course contents has made the students conscious of the link between what they learn in the classroom and industry. It has trained them to take a contextual approach to productivity improvement and technology. Employers are looking for attributes such as problem solving skills, adaptability, initiative, creativity, communication skills, technology literacy, real work experience, leadership ability, logic and reasoning, etc. What better way can all these be imparted into the students than taking them to the industry that put so much emphasis on them? The benefits from the approach is of twofold; the student and the industry perspectives.

Student Perspective:
The students have demonstrated three important pedagogical stances. The first was strategic pedagogy; as they have to deal with the demand of their industrial supervisor; they realized that

they had to do more than adopting effective means of passing the course. The second was pedagogical autonomy, even though they had an industrial supervisor who acted as their mentor, their ability to be independent in making decisions about what and how to learn was never compromised. During the process, students were usually left to make critical decisions on their own. The fact that each group had to decide on what to include in their design to effectively solve the problem gave them much room for pedagogical autonomy. The third was reflective pedagogy; we wanted the students to be able to realize that there are valid perspectives other than their own and that all kinds of knowing will help them to know the world better. The fact that they worked with an academic supervisor as well as an industrial supervisor gave them ample opportunity to be exposed to different perspectives.

Industry Perspective:
The company has been able to improve on its operations through this initiative. Since the initiative started, the students have been able to improve on some aspects of the company's operations. For example, work-in-process inventory has been eliminated, some of the workstations have been implemented as designed by the students and workers have commented on such benefits as "It is great that we do not have to stand all day to get things done." One worker exclaimed on our second visit " Are you guys going to do what you did last year in all the plant, because I think what you did last year was great, since all those changes, I don't have swelling in my legs because I walk shorter distance to get everything I need to do my work now." Above all, all these were done at no extra financial burden on the company.

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