Collaborative Learning in the Construction Technology Curriculum

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Introduction/The Need

As is the case for all disciplines, the skills that the workplace requires of engineering/technology graduates have changed over the years in parallel with evolving technologies and socio-economic requirements. The National Science Foundations's task force on TQM has the following definition for contemporary engineering education ': "Quality engineering education is the development of intellectual skills and knowledge that will equip graduates to contribute to society through productive and satisfying careers as innovators, decision makers, and leaders in the global economy." It is expected that today's engineering/technology graduates will be changing jobs several more times compared to a decade or two ago. This inevitably leads to the requirement that emphasis given in higher education to skills and attributes that are transferable from one type of endeavor to another be as much as, if not more, than that given to purely technical skills, which become obsolete quickly in face of rapidly evolving and changing technologies.

In line with above, it is anticipated that the following would be the skills that the engineering and technology graduates will increasingly be required to possess:

- communication skills,
- cognitive skills,
- leadership skills,
- decision making skills,
- critical thinking skills,
- teamwork skills,
- knowing how to be responsible and accountable,
- knowing how to be sociable,
- being able to understand and appreciate diversity and being sensitive to it,
- being able to handle information as a generic tool that can be used under diverse contexts for solving different kinds of problems.

As the still dominant instructional technology in the engineering and technology education, "lecturing", does not necessarily focus on or enhance the requisite skills mentioned above. It is not realistic to expect that students will become better communicators, leaders, team members, or critical thinkers just because a faculty member lectures to them. It is no wonder that technical graduates which lack the above skills/characteristics (often labelled as "liberal arts educational objectives") rarely occupy the policy formulation and decision making positions in our increasingly technical society, to the detriment of us all.

In view of above, it is increasingly questionable that traditional way of instruction in terms of "lecturing" is the most effective way to educate our students in engineering and technology. Lecturing, a proven way of conveying information, facts, and procedures in a linear and passive fashion, has survived so far because it is convenient and less threatening to the faculty even though its real merits as an educational technology can be questioned. Wankat[2] says that "faculty cling to lecturing because it gives them power, minimizes risk, and is socially acceptable within their departments."

In addition and perhaps more importantly, it is reported that[4,5] there is extensive research showing that lecturing promotes memorization and subsequent recitation of information and procedures without necessarily producing an understanding, that is, without really ensuring a capability on the part of the students to put what has been learned into use in diverse settings different from the classroom setting. Schoenfeld[6] voices the same concern by pointing out that "It's not what students "know" but how they use it. "

Collaborative Learning

Collaborative Learning is defined as [4,5] "instruction that involves students working together in teams toward a common goal." They cooperate with each other to complete an undertaking, with each student feeling responsible and accountable for the final outcome. In this method of learning, after a point, the faculty serve as coaches while students create their own knowledge/understanding by discussing and "doing" together (i.e. experimental learning 3).

Inherent in this approach are collaborating groups or teams which can be in terms of:

Informal groups: Groups of short term, brought together on a random or semi-structured basis during a class period to solve a problem, answer a question, or do hands-on work to break the monotony of a lecture dominated class and focus students on the main theme for that period of class.

Formal groups: **groups for longer periods and longer undertakings involving group research and class presentations, laboratory work, computer work, etc.**

Base Groups: **Groups for periods even longer than for formal groups, extending up to the whole semester or quarter, for long term undertakings related to a class.**

There are specific advantages due to the group approach inherent in collaborative learning. Students feel less threatened and intimidated in sharing their knowledge with their partners in a group, than in trying to show their knowledge to the faculty member or to the whole class first hand without having had an input from their partners. Grouping, if done properly, will preferably bring good students together with students who need improvement. This combination leads to better learning for both parties. All faculty members know that one learns best when one teaches and this is where the advantage for the good student lies. The other student's learning is enhanced in the process as a result of individual attention and tutoring he/she gets. For students needing improvement this method provides better feedback in showing where they stand with respect to others in the class than would be provided by feedback in terms of grades or grade differences. For formal and base groups cooperating for a longer duration, a common bond develops between the group members due to sharing of knowledge and concerns, which leads to a decrease in attrition and increase in retention.

The collaborative learning approach, combined with meaningful assignments, inherently promotes mutual discovery, integrating knowledge, applying knowledge, and transmitting knowledge between students. These are the most important aspects of scholarship and learning, as elaborated on by Ernest Boyer[2] for faculty, which I feel are equally true for the students.

Students collaborating with each other and working on challenging assignments provided by the coach (faculty member) actively create their own knowledge. This is because knowledge is what results from application of information for a particular purpose. This premise makes students aware of the learning process itself and how their own learning takes place, namely "metacognition," greatly enhancing their cognitive and critical thinking skills. Using problems of appropriate variety, this approach also provides the understanding

that information is a generic tool that can be used in diverse settings and contexts to solve different kinds of problems. This instills in students a high self esteem for handling different challenges that come along.

Working in a group inevitably requires teamwork, communication, decision making, leadership, and socialization skills, as well as, group and individual accountability and responsibility. So, when students are collaborating on different undertakings related to their majors, these skills which are generic and readily transferable across disciplines are being transparently imparted and continuously reinforced in a simultaneous fashion.

Requisites for Success/Demands from the Faculty Member

No matter how great an educational technology collaborative learning is, enhanced learning will not take place just because students work in groups. The first and foremost requisite is that there must be a challenging and instructive problem that will draw the group together and drive them towards a goal. As indicated by Smith,[4,5] collaborative learning groups are not discussion groups and unless there is a goal state at the end of a challenging undertaking, the advantages of collaborative learning will not necessarily materialize.

The faculty member must form the groups (especially in the case of formal and base groups) so that over-achievers and under-achievers are brought together for the benefit of both. No matter the type of group, the faculty member must track the progress of the group closely. The faculty member must make sure, through appropriate policies, that some students are not always being "carried" by the others without contributing to the group. Group composition changes must be made expeditiously, if and when needed, as indicated by tracking of group progress and working relationships.

There will always be students who are very comfortable with the traditional passive lecture approach. This is in general due to the fact that depending on the type of course, this approach may not require them to do anything, sometimes for several class periods. Consequently, these type of students are not particularly thrilled with the idea of working with others actively to produce something on an ongoing basis. This perspective needs to be eliminated as early on as possible by explaining the rationale behind using of the collaborative learning approach and the benefits expected which are highly compatible with the today's workplace.

Implementation

I have used and continue to use collaborative learning in all of my classes, more in some than in others, in the Construction Technology curriculum at Indiana University-Purdue University at Indianapolis (IUPUI). I will summarize these undertakings in principle below:

- Collaborative Undertakings using Informal Groups: (Group size: two students)

a. Rather than simply lecturing on the text part of a topic, material is covered in summary, highlighting the important points, and then students work, collaboratively, on detailed in-class exercises prepared for the lecture topic.
b. For courses or topics that involve problem solving, in-class problems are worked on, collaboratively, by students, in groups, after a few examples.
c. At the end of each topic/chapter that has had problem solving undertakings, a problem quiz is given to informal groups who share the grade. Such groups are somewhat semi-structured in the sense that each student must have a different partner each time.

I use all the approaches I have mentioned above at all levels of classes, freshmen through senior, and for all types of classes, lecture through problem-solving, such as Construction Systems, Construction Methods and

Materials, Mechanical Systems in Buildings, Foundation Systems, Construction Field Operations, Engineering Economics, and Hydraulics and Drainage type of courses.

In order to prevent certain students becoming a constant "burden" on their partners and getting a high grade without a real collaborative contribution, I cap the in-class collaborative exercise, quiz, homework, etc., grade of the students by the average of their exam grades which are done individually. The rationale for this is that a student can be a non-contributor a time or two and this is allowed and will not hurt his or her grade provided learning takes place and the non-contributor eventually benefits from the cooperation and also begins to contribute himself/herself. The cap has proved effective in curtailing passive and indifferent attitudes towards collaborating and has promoted individual responsibility.

- Collaborative Undertakings using Formal Groups: (Group size: 2-3 students)

a. I use formal groups for collaborative learning in terms of assignments that require use of computers and commercial or custom developed software for their solutions in courses such as Foundation Systems, Engineering Economics, Soils Testing, Mechanical Systems in Buildings, Construction Field Operations, and Construction Systems. I have a number of custom designed assignments whose solution requires use of knowledge-based expert systems applications that I have developed for these. Expert systems are inherently goal oriented tools which have great capabilities in terms of being able to look at problems with "what if' type of questioning, enabling sensitivity analysis and decision making. Other assignments necessitate working with spreadsheet and other commercial software. This type of collaborative undertakings inherently facilitate students working together on problems of nature that they will be exposed to in their outside work in the industry after graduation.
b. I also use formal groups for some laboratory work and writing of laboratory reports in courses such as Soils Testing Laboratory, and Construction Materials and Methods.
c. I also employ formal groups of 2-3 students for semester project assignments that may involve model building, portfolio preparation, and analysis/design type of assignments that cover almost everything covered in a class. Courses such as Mechanical Systems in Buildings, and Construction System have been involved. Group presentations may or may not be required in such undertakings depending on the type of work assigned.

- Collaborative Undertakings using Base Groups: (group size 3-4 people)

I employ base groups usually for the duration of the whole semester in senior level classes such as Construction Field Operations, Foundation Systems, Hydraulics and Drainage, and Engineering Economics. The work assigned may involve:

a. A library research type of undertaking that results in a research paper.
b. An in-field/industry type of research that results both in a report, as well as, a group presentation in class where each and every member of the group must share in the presentation.
c. A combination of the above two in terms of both in-field, as well as, library research, resulting in a group paper as well as a group presentation.

Conclusions

I have been applying collaborative learning techniques for the past three years or so. Consequently, my evaluation of the outcomes of my implementations are mostly at the formative stage right now with student responses being determined by means of questionnaires and informal talks. Students are well aware of the

inherent advantages of collaborative learning and seem to support it overwhelmingly. In actual practice, however, it still is a problem to get the shy students and the students brought up on individualistic and passive educational methods to accept the drastic change in the instructional approach.

Based on my observations so far, I believe that, computer-based activities and multimedia will play an even significant role in collaborative learning type of instructional techniques in the future. This is because of the fact that however intimidated some students may feel by computers at times, being able to do tasks using computers is an inherently satisfying feeling that pleases them all and gives them a sense of accomplishment in using contemporary technology. This feeling coupled with challenging assignments that will require the use of computers can be exploited to take advantage of the positive outcomes of collaborative learning. This will result in "direct" benefits in terms of enhancing skills such as cognition; critical thinking; problem solving; knowledge generation, integration, and application. It also will result in "indirect or transparent" benefits in terms of enhancing communication, leadership, teamwork, decision making, individual responsibility, individual accountability, and social interaction skills of the students.

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