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ROLE OF TEAMWORK FOR ACTIVE LEARNING IN ELECTRICAL ENGINEERING EDUCATION

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ABSTRACT

In engineering education, a project can rarely be completed without the involved students having to read extensively and search for extra information not available in their textbooks, lecture notes, or laboratory manuals. Students have to find extra information for their research-projects and combine them with their knowledge from the other courses. This important objective opens students' eyes to the realization that the degree by which they have digested the fundamental ideas of their core lessons will dictate their ability to access more knowledge because they appear to face paradoxes when confronting new situations. The merits of teamwork have been sacrificed for the sake of giving the student a very clear idea of the meaning of scientific research and significance of published material. It is expected to aid the student in a future research-oriented career. Teamwork will increase the amount of time spent on out-of-class learning as defined by the student, can be more effective than in-class time, particularly if the focus is learning on higher order learning. The authors believe that the student will be sufficiently exposed to teamwork values during their future design projects.

Keywords: Teamwork

INTRODUCTION

One of the features characterizing university education in our age is a focus on professional preparation and a vocational emphasis. This is accompanied by greater attention to developing the skills required to be a lifelong learner who can adapt effectively to new situations and respond to changed circumstances. Another notable feature is the extensive use of information communications technologies in higher education and the acknowledgement of the need to teach students with and about these technologies (BUTUN, 2004). While these are common across higher education they are particularly salient in engineering education, where there have been major changes to engineering practice and to the expectations and requirements of engineering education. In the USA, the recently developed accreditation outcomes of the Accreditation Board for Engineering and Technology (ABET) require the broad education to understand the impact of engineering solutions in a global and societal context. These impacts include political, economic, religious, environmental, communication and aesthetic considerations. It is identified that there is need for engineering curricula that integrate science and society. A challenge facing university teachers is how to incorporate these new dimensions of curriculum into an already full programme. It is acknowledged that the development of students' skills and understanding in these generalizable and transferable skills is a necessary dimension of professional education. Despite this there is a lack of descriptions of strategies that teachers can use to develop students' skills in a sustainable way. One approach to teaching that appears to offer a solution to this predicament is that of active learning. Teaching approaches that involve a more discursive and collaborative approach to problem-solving and that seek to illustrate and accommodate diversity provide a means by which students can develop discipline-specific and generalizable skills and knowledge. Active learning approaches create situations where students are truly engaged in solving problems through reading, writing, talking and acting on them. Active learning engages students in higher order thinking tasks as analysis, synthesis and evaluation (MCALPINE, 2004). Active learning methods attempt to develop the cognitive, knowledge, understanding and thinking and affective, emotive dimensions of the learning process in such a way that learners' active involvement in the learning is improved. Active, engaged learning can be achieved through the use of a wide range of teaching strategies, including collaborative learning, problem-based learning, case methods, enquiry-based learning, and combinations of role-plays and simulations.

The etymological meaning of the word learning goes back to the concept of discovering. Hence, the origin of learning is rooted in activity, doing something in order to find out about the world. Active learning and engineering education constitute a natural pair. An engineer is trained to design and construct solutions to problems in the real world. Evidently, the discussion in engineering education does not stop at the contents of the curriculum. The goal is not to fill our students' heads full of knowledge, but to provide a well-adapted learning environment, which allows them to "learn to learn", and enables them to acquire the combination of knowledge, skills and attitudes needed to obtain professional engineering competencies. Activating students is both an effective approach in the didactic sense as well as a fitting preparation for practice. Today most engineering schools work with one or another variety of active learning. Consequently there are many examples of good practice. However, the choice of methods is often determined largely by incidental factors.

What teachers see of the process is largely what is observed in class, such as students' note-taking and asking questions, as well as sometimes out of class interactions such as visiting the office. These observations, the tip of the iceberg, provide little insight into the invisible aspects of the learning process: how the students conceive the learning task and what strategies they use both inside and outside class to achieve what they believe they should be learning. Yet,

ultimately, these largely invisible learning results in some products, such as exams and assignments, that are graded, assessed summatively.

The use of Total Quality Management (TQM), resulting in teamwork in industry has had a deep effect on the ability of companies to produce a higher quality of goods and services in an increasingly competitive global marketplace. Forming teams in the classroom has a similar effect by being able to produce a higher quality of goods (students) and services (experienced-based knowledge) through participative classroom experiences (ETTARO, 2000). The purpose of this paper is to investigate the use of teams in higher education, particularly industrial technology programs with the focus on assessing the performance of individual students working in quality teams. The findings support the method used for determining individual performance in teams with a strong correlation to other indicators of individual performance.

In this paper, we describe the a new design and use of a teamwork which engages students in learning about specific knowledge in electrical engineering research projects while developing common skills and understanding about the complexities of decision-making and collaboration and an understanding of development. The goal of this paper is to provide a mental model to overlay decisions about instructional activities in order to assess the extent to which the decisions align with theories of learning and research in engineering education.

CONSTRUCTIVISM

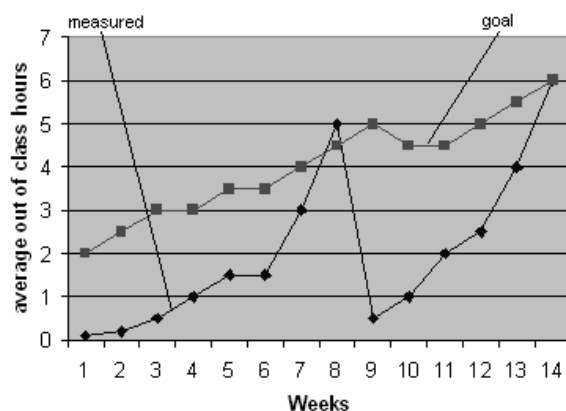
Constructivism is a philosophy of learning based on the premise that knowledge is constructed by the individual through his or her interactions with the environment. It has its roots in the constructivist movement of cognitive psychology, which holds that individuals gradually build their own understanding of the world through experience, maturation, and interaction with the environment, including other individuals. Thus, from the constructivist viewpoint, the learner is an active processor of information. This is in sharp contrast to behaviourism. Constructivism comes in many flavours and some constructivists take on extreme or radical views, such as the belief in the non-existence of objective reality because each individual constructs his or her own meanings. A more pragmatic view of constructivism is to maintain that knowledge is the product of many learner-centred processes, to include the social process of communication and negotiation (BUTUN, 2004; ROVAI, 2004). Differences in traditional and constructivist learning environments are listed in Table 1.

Table 1. Comparison of traditional and constructivist learning environments

	Traditional	Constructivist
Instructional emphasis	Teaching, knowledge reproduction, independent learning, competition.	Learning, knowledge construction, collaboration, reflection.
Classroom activities	Teacher-centred, direct instruction, didactic, individual work.	Learner-centred, authentic, individual and group work.
Instructor roles	Expert, source of understanding, lecturer.	Collaborator, tutor, facilitator, encourager, community builder.
Student roles	Passive, listener, consumer of knowledge, note taker.	Active, collaborator, constructor of knowledge, self-monitoring, assessing
Assessments	Reality retention.	Knowledge application, portfolios, projects, performances.

The implications of constructivism for a learning environment include using curriculum customized to the students' prior knowledge, the tailoring of teaching strategies to student backgrounds and responses, and employing open-ended questions that promote extensive dialogue among learners. Questioning, therefore, becomes the major means by which students are helped to construct meaning. However, according to (BROOKS, 1993), the constructivist approach is more than just activities. In not treating students as passive learners, more respect is shown to students as learners and as human beings. It is very important for the instructor to be aware of initial student misunderstandings to provide the kinds of experiences that will allow the student to learn. It is this pragmatic view of constructivism that provides the philosophical basis for this article.

Figure 1. General weekly out of class times. 8. and 14. weeks are assigned for midterm and final examinations respectively.



Much of learning occurs out of class in engineering education and there is a graph that provides information about the amount of time that it would be reasonable to spend on learning. As it can be seen, out of class hours are high values in examination weeks. Student time-on-task studies document that time spent on out-of-class learning, as defined by the student, can be more effective than in-class time, particularly if the learning focuses on higher order learning, such as problem solving (KNAPPER, 1995). The amount of time spent on out-of-class learning varies by nation. Undergraduates in Europe report spending between 1.5 and 3 hours out-of-class for every hour in class, whereas students in the US report around 1 hour out-of-class for each hour in class (MCKEACHIE, 1999). A reasonable expectation might be that students spend up to 2 hours out-of-class for every hour in class as in our study. In other words, to encourage a deep learning, the time spent on learning tasks for a course for an average student should not exceed this amount of time. Authors claim that being a good member of a team will contribute increasing out of class learning.

WHAT IS QUALITY?

Official definitions of quality terminology were standardized in 1978 by the American National Standards Institute (ANSI). Quality is defined as the totality of features and characteristics of a product or service that bears on its ability to satisfy given needs. The ability to satisfy given needs reflects the value of the product or service to the customer. Five different approaches can be given to define quality.

- One common notion of quality is that it is synonymous with superiority or innate excellence. It is called as transcendent definition.
- Product-based definition is that reflect differences in quantity of some product attribute.

- Quality is determined by what a customer wants and what they are willing to pay for. This leads to a user-based definition: quality is defined as “fitness for intended use”.
- Quality is a manufacturing-based process. So quality is defined how well manufacturing or service delivery is able to meet the design specifications.
- Value-based definition states that quality is defined in terms of costs and prices: a quality product is one that provides performance at an acceptable price or conformance at an acceptable cost.

LEARNING IN TEAMS

Teams are often defined as groups of people working together to achieve objectives that are shared. However, it can be very cumbersome. Therefore, students and lecturers must learn why groups can face two kinds of problems:

1. Cognitive problems arise because team members have to organize their intellectual activity so that they all think clearly about the issues and develop a shared understanding of what is happening and why it is happening.
2. Political problems arise because team members have to accept direction and give up some of their autonomy.

Students simply have to learn to take responsibility for their own situation and learn to appreciate that it is a lifelong situation. Doing teamwork is more than ever a skill needed and it will be an important part of the career of the future engineer. The project work has to be completed within the time schedule and to be presented at an assessment meeting at the end of the semester. Great attention is paid to the ability to plan, navigate, delegate, communicate and co-operate as a team towards a common objective. Teamwork is the ability working together towards a common vision, directing individual accomplishment towards organizational objectives. Teamwork involves several skills such as:

- Selecting members of a team
- Adapting complementary team roles such as coordinator, reporter etc.
- Behaving cooperatively
- Coordinating team meetings and reporting performance
- Interpersonal influence, negotiation, discussion and argumentation
- Creative problem solving and willingness to build upon ideas of others
- Understanding of the team process
- Leadership at appropriate times, positive attitude, initiative and listening and seeing

Groups are formed generally with four students under following considerations:

1. Group members should have close residence
2. Every group member has a specific task as,
 - A coordinator, to plan organization list of task,
 - A reporter, to make reports,
 - A diplomat, to get in touch with other groups and present the study.
3. And other members according to individual design projects.
4. Every group should have their own constitution for meetings and should prepare a weekly report to inform the other group and teacher they have already done in meetings.

5. Presentation time is limited with 10 minutes for every group, but there is no limited time for discussion.
6. Groups used Data Show and a computer to make their presentations.

WEEKLY ACTIVITIES

Groups were required to make at least two meetings in every week, in which first of them prepare a task list according to group members' positions and the second meeting is for evaluation before the lesson. Groups were also required a self-report of every stage of the study, and were also reminded that they could contact with the teacher through e-mail, telephone and visiting the office at any time they encountered with any problems or difficulties. In doing so, we wanted our group members to be the observers of their own study as well. The relationship between the teacher and the group members required trustworthiness in order to reach at the most positive results.

Rules for designing a good agenda and a good report of the weekly meeting are also provided. The following points are suggested on the agenda:

1. Approval of suggested agenda.
2. Short evaluation of last meeting.
3. How are the project and teamwork developing?
4. Any other business and next meeting.

At the first meeting, we tell students, we expected of them,

1. to take responsibility of their own learning.
2. to contribute actively in the teamwork.
3. to be trustworthy
4. to take ownership of their situation, time and project.
5. to develop a 'we-attitude' in their team, and
6. How can they join their own effort with the effort of others to achieve a greater success?

TUTORIAL MEETINGS

It is essential for the overall supervisor to guide by example and have regular feedback through tutorial sessions, and at least one weekly meeting with the team is required.

Rotation of duties, such as coordinator and report functions, ensures equity of responsibility and assessment.

Discussion meetings are arranged in agreement between a team and its coordinator.

The aims of those sessions are to develop and improve communication, oral presentation skills, discussion skills and critical thinking. All presenters receive written feedback from every member of the audience using standard feedback sheets. The following areas are assessed:

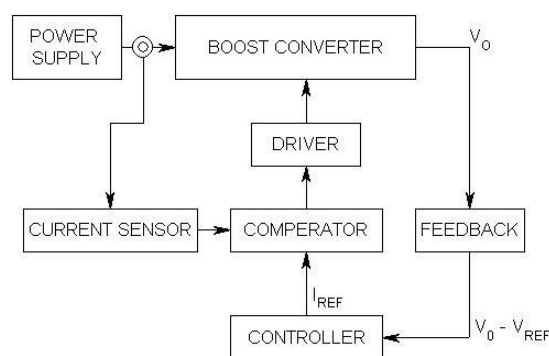
1. Understanding of problem area.
2. Delivery style.
3. Use of visual aids.
4. Clarity of explanation.
5. Adherence to time.
6. Handling of questions.

In the tutorial meetings, we aimed to develop critical thinking with identifying arguments and being able to see the difference between arguing, explaining and summarizing. As well as having reasons and conclusions, an argument should be persuasive. Developing critical thinking, we have found, contributes to educational performance.

During the weekly meetings, the teacher acted as a facilitator to provide the group members rich environments and activities to solve the problem. His role included meditation, modeling and coaching. When mediating the group members' learning, the teacher frequently adjusted the level of information and support which the students needed and he helped them link new information to their prior knowledge and referred their problem solving strategies. He held lessons as another meeting with the groups every week in order to check the ongoing processes dealing with the study. In those meetings the groups self-reported the processes at each stage of the study, and the teacher and other group members listened to them, and discussed the problem with the students like a learner. Group members should take active role in generating learning issues, deciding how they will study them and evaluating what they have learned during the reporting. This process is essential in the development of students' self-directed, life-long learning skills.

WHAT CHARACTERIZES A DESIGN-PROJECT?

Figure 2. A sample design-project: Boost converter.



All projects are real-life team-based actual projects. The project period is considered as a work process of integrated teamwork resulting in a group project report. The professional content and communication also characterize a project. All of the projects have one input from another project and one output to another project as consumers to complete a chain as in total quality management. So as we defined in the introduction, consumer quality awareness puts a greater strain on project and consumer demands and dynamic changes open up new and highly competitive learning environment. Before each semester we define a design-project title such as intelligent buildings, converters, instrumentation, process control, and modelling-simulation etc. and leave it to the student to choose a project of interest and motivation from this title. Normally students choose a project where they can use their area of study.

PROJECT MANAGEMENT AND PERFORMANCE

Students learn during this research-project how to manage engineering projects. Each team is involved in defining, systematizing, planning and navigation of their own project according to their consumer. On compulsory weekly meetings things such as project development, teamwork problems, communication problems and cognitive and political problems are discussed between supplier and consumer groups listed in Table 2. In brief the three main areas are kept in focus as project (general), process and group members. From those weekly meetings students learn good meeting techniques and disciplined behaviour. Further,

they learn how to work out minutes and to make a good agenda. Also, the ability to listen, discuss and negotiate solutions in place is developed.

Table 2. Group task organisation of design project according to total quality principles.

Supplier	Consumer
Power Supply	Group A: Current Sensor and Comparator
Group A: Current Sensor and Comparator	Group B: Driver
Group B: Driver	Group C: Boost Converter
Group C: Boost Converter	Group D: Feedback and Controller
Group D: Feedback and Controller	Group A: Current Sensor and Comparator

GROUP MEETINGS

The purpose of group meetings is to allow students to report on the progress of their project work to the other groups. Full use of visual aids facilities is expected, and each presentation is followed by a discussion at which the diplomat is expected to defend the work done. Students are expected to take an active interest in fellow students' work, to contribute ideas and to provide constructive criticism. The group meetings serve a number of important functions:

1. Presentations provide a tool for maintaining peer pressure through the need to express regular commitment to achievable objectives within fixed timescales.
2. Preparation for an oral progress report provides an opportunity for the student to review and have another look at his/her work.
3. The meetings provide an opportunity to develop presentation skills including the ability to defend a line of reasoning or a course of action.
4. Provide the students with the opportunity to acquire information on other projects related to different problems, thus gaining exposure to diverse fields of study, and obtain a wider engineering understanding.

ANALYSIS

A detailed questionnaire in the appendix was given to 25 students at the beginning and end of the process for evaluating the difficulty level of the problem, effectiveness of individual and teamwork and learning contribution of the chosen problem. Following statistical analyses are done to demonstrate advantages of the applied method.

CORRELATION TEST

The correlation coefficient is a measure of linear association or clustering around a line. The relationship between two variables can be summarized by giving the correlation coefficient. Coefficient of simple correlation can be calculated directly from (NETER, 1988),

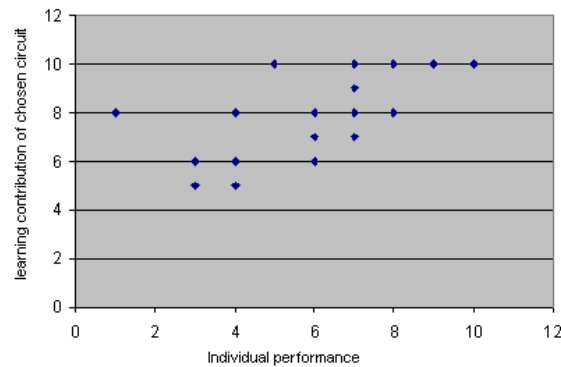
$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2 \sum(Y_i - \bar{Y})^2}} \quad (1)$$

Correlations are always between -1 and +1, but can take any value in between:

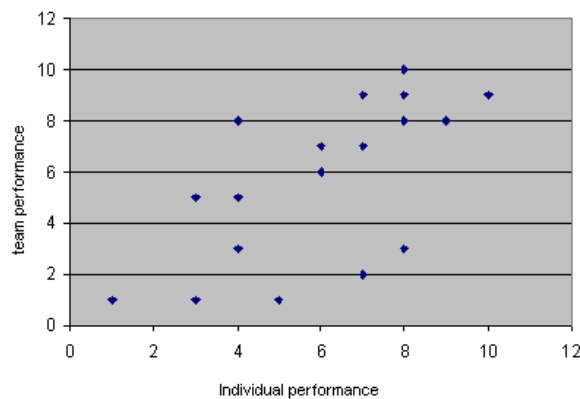
- A positive correlation means that the cloud slopes up: as one variable increases, so does the other.

- A negative correlation means that the cloud slopes down: as one variable increases, so other decreases.

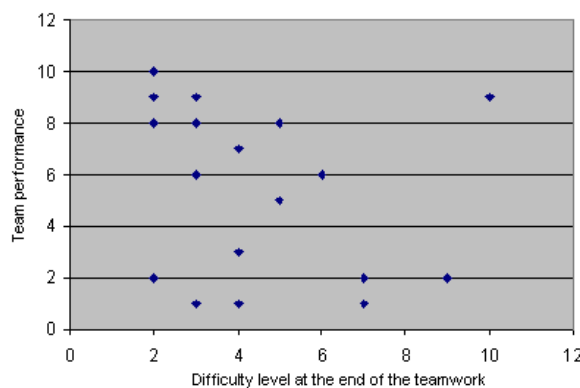
According to the given inquiry, following comments are done:



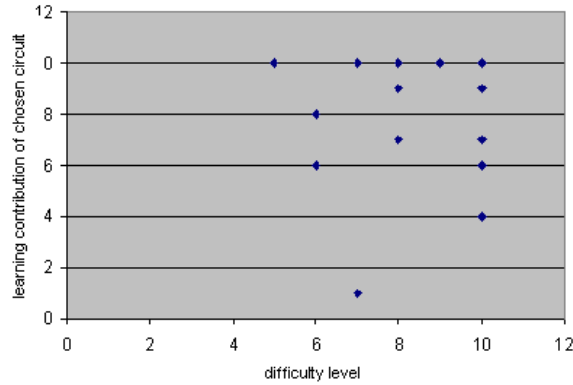
- Individual performance of students in the team and learning contribution of chosen circuit have positive correlation with values of calculated values of $r = 0.656$ ($p < 0.01$). That means, as individual performances of students in the team increases, so learning level and transferring knowledge increases too.



- Individual performance of students in the team and performance of the team have positive correlation with calculated values of $r = 0.586$ ($p < 0.01$). That means, as individual performances of students in team increases, the team performance increases too.



- Students' evaluation of difficulty level of the problem and performance of the team have negative correlation with calculated values of $r = -0.326$ ($p < 0.01$). That means, as teamwork performances of students in team increases, the difficulty level of the problem decreases.



- Students' evaluation of difficulty level of the problem and learning contribution of chosen circuit have negative correlation with calculated values of $r = -0.401$ ($p < 0.01$). That means, learning process, concentration and teamwork are helpful tools for understanding difficult problems.

CONCLUSION

Adapting to this new style of active learning can initially be stressful for most students. They were formerly used to being given lots of instructions and directions about what they need to cover and now they are on their own and other group members. We have,

1. captured the students' attention by collaborating with actual projects and applying pressure on students if necessary;
2. attempted to give students the "training of the mind" for problem identification;
3. encouraged students to think outside of their comfort zone, expertise, experiment, change their routines and think laterally.

Students have,

1. learned how to use all of the resources available to themselves,
 2. realized the wrong things and/or right things during their discussions in the lessons. Thus they learned individually and collectively,
 3. tried to understand the interdependency of the problem with their knowledge.
- and,
4. generated working ideas or solutions,
 5. identified available information related to the problem,
 6. identified learning issues and resources to look up or consult gathered information,
 7. proposed a solution.

During evaluation sessions early in the course, most students reported feeling anxious about the time spent searching for relevant resources in out of class times. They are often concerned about obtaining sufficient information in both quality and quantity. This uncertainty regarding the depth and breadth of knowledge needed was the most frequently reported stressor by students starting team work. Other areas can be difficulties in adapting to group learning, misunderstanding the role of the tutor, and impatience in developing self and peer evaluation skills. Students' anxiety is decreased when this is brought to their attention during evaluation

of weekly meetings. Another effective technique is to give an early examination. Although examinations themselves may be stressful, once the students have a benchmark for their course standing, their anxiety is less apparent. After three or four evaluation sessions and a midterm examination, stress appears to be much lower, and the students report enjoying learning.

We have seen this method of teaching improved student understanding and increased out of class hours. Learning is a manufacturing-based process, and is defined how well manufacturing or service delivery is able to meet the design specifications as in quality processes. As tutors, we regularly observe the rapid progress in our students' understanding of new and difficult concepts and their growth in personal and interpersonal skills in group learning. Foremost among our students' opinions was that they liked the course because they were not told what to learn and were treated as adult, self-directed learners. This is one of the aims of total quality teams, and expectantly this self-directed learning will continue throughout their careers.

Individual performances of students in the team effect the learning level and transferring knowledge directly. The importance of teamwork is highly emphasized by many educational establishments as well as by industrial representatives, who integrate questions concerning these projects in their interviews of fresh graduates seeking employment.

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