Introducing Innovation to Undergraduates through the Engineering Team Project (ETP) Course

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Abstract The overall framework of the Engineering Team Project (ETP) course at Universiti Teknologi PETRONAS is discussed here. ETP is a three hour credit course offered by UTP to all third year engineering students. This group project course involves members from various engineering backgrounds. Such an approach gives students an idea of real-life engineering project work, where multi-disciplinary and cross-functional input is required at many levels. Initially geared towards giving students an early exposure to project implementation, it has been modified to train students on how to be innovative. The basic course structure, assessment methods, the modifications made to train students to be innovative and the results from the modifications are described.
Key words introduction to innovation, team project, multi-discipline

1 Introduction

Engineering deals with the science of designing, creating and applying technology including machines, structures and products. The largest branches of engineering are mechanical, electrical and electronic, civil and chemical engineering. Engineers must acquire specialized knowledge and skills used for the benefit of society, honesty and impartiality in engineering service, desire to improve the profession continuously, and support the professional and technical societies that represent the professional engineer. An engineer's nature of work involves constant interaction among fellow engineers and professionals from various fields, as well as outsiders. Simulating this during a student's undergraduate years is typically not carried out.

At Universiti Teknologi PETRONAS (UTP), a course has been introduced to expose undergraduates to such an atmosphere. It is called Engineering Team Project or ETP, and is a 3-hour credit course [1,2]. It is offered to all Third Year Engineering students in UTP as a core course. The course was developed and introduced to all engineering courses at UTP in line with the university's mission of producing 'well-rounded' graduates who are creative and innovative with the potential to become industry leaders and the nation. The qualities of such a graduate are defined as follows: possess technical competencies, lifetime learning capacity, critical thinking, communication and behavioral sills, business acumen, practical aptitude and solution synthesis ability. The intent of ETP is to bring a semblance of an engineer's working environment into the university. This is in tune with the university's multi-mode course delivery strategy.

At present, ETP is managed by the Mechanical Engineering Department. The course was initially designed to ensure that students would acquire the knowledge in conducting research and development work. This would include conducting literature research, preparing a project proposal, coming up with initial design concepts, modeling, evaluating and designing the best concept, and producing the working model or prototype.

The essences of ETP are Teamwork, Creativity, Originality and Engineering Fundamentals. These feed into the main objectives of the ETP course. These include to instill teamwork spirit in the students, develop leadership competencies as well as technical ability especially in managing various parts of the project, analyze engineering situations, perform engineering design, enhance computer related skills such as on the use of simulation software and Computer Aided Engineering (CAE) tools, use word processing and project management software, better understand the industrial equipment available around them as well as gain knowledge on preparing project proposals. Students are put together in a group consisting of members from various disciplines and learn more about other engineering. On top of that, these students are also of different races, nationalities and gender with differing backgrounds, much like that they will experience in industry. This would not normally be taught to the students through conventional course instruction.

Increasingly, the industry is putting more focus on the need for its staff to innovate. Many deem innovation to be a gift for a few, more like an innovators' gene rather than a skill that can be trained. At UTP, emphasis has been placed on innovation training and ensuring that the students innovate as much as possible during the ETP as a prelude to future engineering work. The results have been very encouraging, and are presented in this paper.

The objective of this paper is to highlight the running of ETP, the basic assessment methods used to evaluate the students' performance and how the course is modified to teach students how to innovate.

2 Management of ETP

A main ETP Committee manages this course, typically consisting of two mechanical engineering lecturers and assisted by one tutor, if available. This committee reports directly to the Head of Mechanical Engineering Department. This committee's main role is to implement and manage the course. This includes assigning students to respective groups, organizing technical presentations for the students, compiling topics of projects, advising supervisors on any problems encountered during the project work, seminars, poster presentations and compiling students' results.

Each group would consist of between four to seven students from various engineering departments in UTP, namely Mechanical, Electrical and Electronics, Chemical and Civil Engineering. Each group would have one engineering lecturer assigned to them as the main supervisor. The supervisors' main task is to evaluate the project proposal, advise students on the project preparation, guide the group's progress and monitor the project progress against the group's initial plans. The supervisors also have to assess the group performance through progress report, final reports and oral presentations. Figure 1 outlines the structure of ETP including the support infrastructures put in place.

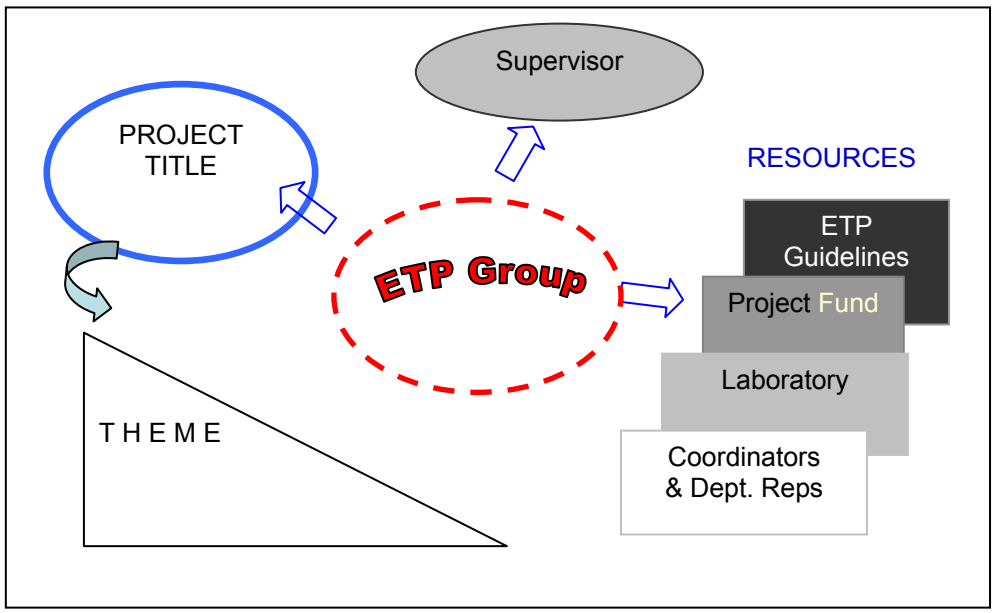

Figure 1 Schematic outlining the structure of ETP

Each group is required to come up with conceptual designs, perform engineering calculations to support the design, generate engineering drawings of the selected concept, and develop displays, a working model or prototype to illustrate how the concept will work. The students usually try to make the working model using off-the-shelf components or fabricate it using industrial equipment available.

3 Project Title Generation and Award of Project

3.1 Project Title Generation

Initially, ETP project title were canvassed from all staff or derived from real-problems with no specific collective direction. Early in 2007, to help the groups focus on their work, the ETP Committee first specifies themes for the problem statements. The themes are varied such as Environment, Health, Safety and Environment (HSE), Equipment for the Physically Handicapped and Energy, and it varies

from semester to semester. The themes for the July 2007 semester are listed in Figure 2.

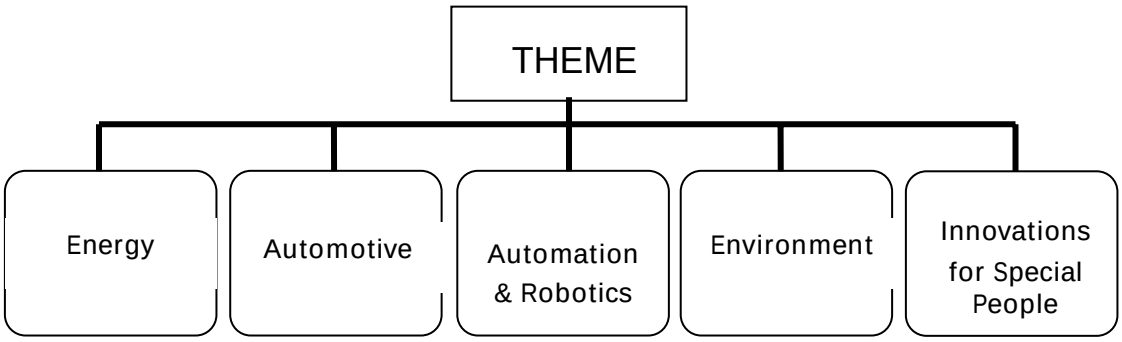

Figure 2 Themes for the July 2007 semester

Since the students come from various backgrounds, naturally the topics for ETP must also reflect this. The topics for ETP need to have interdisciplinary input as much as possible to ensure all the students can participate and contribute to the project. The projects must be as similar as possible to problems tackled by practicing engineers. Instead of specifying the project title straight away, the topics are described to the students in the form of a problem statement. This allows the students to understand the issue at hand clearly and try to come up with a solution that is not bounded by the title of the project. This approach allows great degree of flexibility for the students to tackle the problem from their perspective instead of a prescribed perspective the committee sets upon them.

To ensure that the projects that come under each theme is as interdisciplinary as possible, all academic staff in UTP are invited to specify the problem statement for the proposed topic that they have in mind, along the themes proposed for that particular semester. An introduction of themes also helps the staff focus their suggestions along these specific themes instead of proposing ideas that diverge in all directions. This focus also allows the projects to be aligned with the specific strengths that the university has, especially with regard to expertise and equipment. The topics are screened by the ETP Committee to ensure that they fulfill these initial requirements. If the topic is deemed to be suitable but require some additional input to make it suitable for ETP, the topics are further discussed, and the problem statement framing the topic is further modified. The topics are then placed within the specified themes and advertised to the students for the next phase of award of project, which is outlined in the next section.

3.2 Award of Project

There are several modes of project selection made available to the groups. Students are presented with three options. The first option is designed to simulate the real activity in securing project work. The project is awarded to the group through a form of bidding process. As mentioned earlier, several themes were made available to the student groups to bid. Groups study the themes carefully and select an advertised title from the given list. The group then discusses with their assigned supervisor on the way forward and develops the project proposal based on this. This first option however has been discontinued from the July 2007 semester onwards.

The group may decide that they have a better topic to undertake rather than those listed. They are then free to exercise option two, which is to discuss their topic and put it forth as their project as long as it is within the specified themes. This helps the students with independent learning while at the same time giving some direction pertaining to the type of project they should undertake within the confines of ETP. In the event the groups fails to adopt either of these approach due to any reason, the supervisor will then assign a theme to the group for them to come up with a project. This is essentially option three, whereby the project is still within the guidelines established earlier by the ETP Committee. In any case, groups are then able to proceed along several common themes. One advantage of this is that the students can compare notes across groups, even though their specific projects may differ from one another. This has been found to be very useful for the students as the peer approach is a powerful tool for independent student learning with less dependence on the supervisors.

4 Assessment Approach

ETP has been identified to be a course in which a lot of opportunity exists to train UTP's undergraduates on Innovation. Some assessment aspects of ETP already gear students towards this, but further inputs are made to achieve a more complete package of training. The initial assessment mode is specified at length [3]. Certain modifications have been made in order to facilitate the inculcation of Innovation into the students. Some of these modifications are built into the assessment methods, while some are strongly recommended but not built into the assessment.

In order to inculcate innovation among students, there is a need to identify what innovation is to begin with. There are a lot of variations on that theme, but the general opinion is that innovation is tackling something in a new way that brings benefits not only from a technical but from society angles. Both aspects are emphasized in the Project Proposal that is the first document the groups have to produce that will be assessed. A detailed breakdown of the evaluation steps is outlined in Table 1.

Table 1 Assessment of ETP [1]

Time Frame	Assessment	% of marks
Week 2	Project Proposal	10
Week 6	Progress Report	10
Week 10	Fabrication of Model/Prototype	10
Week 11	Demonstration	15
	Poster Evaluation	10
Week 13	Group Oral Presentation	10
	Individual Presentation	5
Week 14	Final Report	25
	Peer Evaluations	5
Continuous	Individual F-Factor	% of accumulated score

4.1 Concept Selection Process

One of the barriers in innovating is the lack of variety in the technical possibilities generated in trying to solve a problem. To alleviate this, one of the modifications to the course was implemented and is described here. After the groups have selected or assigned a specific project title with a corresponding problem statement, they are advised to come up with a list of specifications that frames their problem statement. This is their Product Design Specification or PDS. These sets of specifications will allow the students to identify the target specifications their final design must meet. These specifications may include operational constraints such as time, since the course only lasts for one semester. The groups will have typically 12 weeks to complete the conceptualization of the solution they will propose. With the PDS in place, the groups are asked to generate various conceptual designs that can tackle the PDS effectively. This is one of the most important steps in teaching students how to innovate.

These variations could be permutations of the same approach, or vastly different concepts to the same problem. The students are then asked to do a technical evaluation of all the concepts generated in order to select the concept they will opt for. The technical evaluation should be as qualitative and quantitative as possible.

The introduction of such quantitative evaluation criteria is essential without which, the students have been found to select concepts based on a group vote without the proper technical evaluation against criteria or specifications i.e. PDS that would frame the problem statement with better accuracy. That is an essential part of ensuring innovative approaches will not fail due to technical failure of the concept to solve the problem at hand. It is also part of inculcating innovation among the undergraduates to ensure that the innovative ideas put together are physically feasible and practical to be carried out. Initially, there was no specific selection matrix used. We have now recommended several approaches, with the emphasis currently on Pugh's Selection Matrix [4]. An example of this method is shown in Table 2.

Table 2 Example of Pugh's Selection Matrix

	Weight	A	B	C	S
Setup	10	5	3	2	4
Operating	10	5	2	2	2
Cost	25	2	5	4	3
Ease of Manufacture	10	2	4	5	4
Time to Market	30	1	4	4	3
Aesthetics	15	4	2	3	4
Total Score	100	260	315	365	315
Ranking		4	2	1	2

During the concept generation phase, students are asked to do as comprehensive a survey as possible on existing designs that maybe similar to the ideas that they have. For ETP, we have included patent search as an important tool in concept generation and selection. Students are asked to carry out a patent search on their design in order to ascertain how similar the concepts that they have to existing ideas are. This particular step also allows the students to expand their idea bank on the available concepts and how they may opt to apply a different approach to improve upon the concepts or integrate a never-before tried method. This adds variety to the concepts that they will generate and even possibly allow the students to come up with an entirely novel project, which is the essence of innovation.

After the concept selection, the students will prepare a proposal based on the selected concept. The proposal will include the problem, the scope and practicality of the proposed design. All this will be done after discussions with the supervisor.

4.2 Project Progress

As the students proceed with their projects, the respective designs are not 'frozen'. As the design progresses, the students are encouraged to make design modifications for improvement, be it from the economy, manufacturing or the operational perspective. Although is real life design are sometimes frozen, this is not imposed upon the students as they are not meant to come up with an exact pre-production device but rather a prototype or working model. One further advantage of this approach is that the same concept can be further improved by other groups for the coming ETP sessions. Through this approach, good designs can be further refined for future work.

43 Seminars

To beef up the students' knowledge on innovation, several seminars were given during the timeline of this course. The seminars revolve around research project management, innovation updates as well as examples of success and failures in the market. The speakers include university lecturers as well as industry experts and accomplished national innovators. Such input will be better absorbed by the students who will have a view on the real world's state of innovation straight from the practitioners themselves. An example is Mr. Bugs Tan who was the winner of Malaysia's National Innovators Award 2007 and has 19 patents to his name.

The seminars are not only for additional knowledge. The content is very much needed for the students' reports, whereby the steps introduced in the lectures are elements in their report marking scheme. Students therefore follow the seminars attentively to ensure compliance to the documentation requirements.

5 Problems Encountered

As with any atypical course, ETP also experiences its own sets of problems. This course does have the advantage of maturing over time, coming into being slightly more than seven years ago. Since this course requires students to work with virtual strangers, it is important for the groups to commence work early. It is essential for the groups to obtain their project titles as soon as the semester starts. To assist in this, students are required to register for this course as soon as possible to assist the ETP Committee facilitate the group formation. Themes are also elicited from academic staff before the end of the previous semester. These are then put up in UTP's e-Learning gateway, where students can access updated information on the courses online.

Another most widely reported problem is the perceived mismatch between the project title and students who are from courses perceived to be unrelated to the project. Since students will also be graded individually, every member of the group must contribute to the project. For example, a student in the Civil Engineering Department may feel that he or she cannot contribute in a project that is very much electrical in nature. To counter this, the ETP Committee points out to students that part of the objective of ETP is to gain a better understanding of other disciplines. The students should have developed enough skills by then to absorb information on another department through the discipline taught through their own courses. This is very much a reflection of the real world today, where most engineering work involves cross-disciplinary interaction for successful implementation.

As pointed out earlier, the groups have to present their projects during Week 13. This could mean that at least 60 groups will have to present their work. Depending on the number of students undertaking this course, the logistical issues related to this is enormous. The ETP Committee has to arrange for the groups' presentations and ensure there will be adequate number of evaluators, usually made up of the academic staff, to assess the projects' quality. The request for evaluators thus has to go out very much earlier than Week 13, to ensure their availability. The same goes for venue and other associated support equipment such as projectors, computers and displays.

6 Selection of Projects for Further Development

UTP being a young university has got a relatively small postgraduate community. This affects the number of research projects being carried out. We do have a pool of talented young undergraduates who have been selected from the best in Malaysia as well as from various other countries. UTP has leveraged on this strength in order to come up with good undergraduate projects with high innovation content.

6.1 Selection Mechanism

Undergraduate projects in UTP are given an opportunity to represent UTP at various external exhibitions. In order to do so, the projects compete in an internal exhibition competition called Engineering Design Exhibition or EDX. This exhibition puts participants in direct contact with the best selected projects from all of the departments in the university. The exposure allows participants to have a better appreciation of the need for cross-disciplinary input and teamwork in developing a new concept.

To be selected, the groups make an initial presentation to the ETP Evaluation Committee, through which the best projects are short listed for entry into EDX. During the exhibition, representatives from UTP's Innovation and Design Committee (IDC) are invited to judge the undergraduate projects and select the innovative ones suitable to represent the university. These projects are then given a deadline and extra funding. The funding goes into improving the project's existing design and presentation material, be it from the model or the posters used as well as the multimedia presentation. This approach gives greater freedom to the project team and supervisors to devise superior ways of highlighting their projects' strength and put it forth is competitions where the judges will be representatives from industry as well as venture capitalists. This will be the closest to a real-life market as these projects will ever come to during the development phase. Bearing in mind the projects are not fully developed for the commercial market yet, the feedback from the commercial and industrial representatives are used for further development of these ideas.

6.2 Successful Forays

Several ETP projects have been selected to represent UTP in national and international exhibitions, specifically in exhibition competitions that put emphasis on innovative ideas. In the International Invention, Innovation, Industrial Design & Technology Exhibition or ITEX 2006, four ETP projects won Gold medals during that event. Out of the four, one received a Gold medal at the recent INPEX 2007 in Philadelphia. Bear in mind that these projects compete in a field usually populated by postgraduate projects from other universities with much greater funding, Table 3 outlines the wining projects and the accolade gathered so far. The accolades earned are a good indication of just how successful the ETP modifications are in inculcating innovation to the students.

Table 3 ETP Projects that have won Awards [5]

Project Title	Award
NETTER Household Water Filtration Kit Using Low Cost Natural Product	- 1st Place EINIC 2006 - Bronze Medal ITEX 2006
Coolcap	- Gold Medal ITEX 2006 - Gold Medal INPEX 2007 Pittsburgh
Smart Messaging Parking System	- Gold Medal ITEX 2006
REVO Badminton Shuttlecock Launcher	- Gold Medal ITEX 2006
Phyllent X-Flies Fly Repellent	- Bronze Medal ITEX 2007
Greenphylic Water Soluble Degradable Plastics	- ITEX 08 Best Invention for Universities/ Research Institutions - WIPO Best Invention at ITEX 2008 - KASS Best Invention at ITEX 2008
Motorcycles' Parking Security System	- Silver Medal ITEX 08
A Signal Detection System to Uphold Exam Integrity	- Silver Medal ITEX 08

7 Conclusion

The modifications to ETP have improved the level of innovation of undergraduate projects. This is evident from the level of success these undergraduate projects have in external exhibition competitions, especially against better funded projects. It is hoped that this will help in UTP's quest in developing well-rounded graduates who are well-versed with basic methodologies needed to come up with innovative ideas especially in the new environment where innovation will be the new driver for economic growth. We at UTP believe this course will be a catalyst for the production of such graduates. The current success of innovative ETP designs is just the start, and we hope to improve the delivery of this course in order to better train our students to meet the challenges of the industry.

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