EFFECTIVENESS OF PROJECT BASED LEARNING ON TRANSFORMING THE GAINS TO WORKLIFE: A FOLLOW UP STUDY THROUGH MARINE ENGINEERING DEPARTMENT GRADUATES

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ABSTRACT

As students learn better and easier by actively participating in the learning process, student-centered learning and teaching environment in engineering programs have become more and more common in higher education. At DEU Maritime Faculty Marine Engineering Department Project Based Learning (PBL) has been applied to senior class students. There has been an ongoing debate about the effectiveness of active learning methods and the number of researches related to the transfer of the skills and knowledge gained by these methods to real life is limited in the literature. A follow up study has been conducted through project team members two years after their graduation. The impacts and effectiveness of Project Based Learning on (1) the programme outcomes of marine engineering department (2)the knowledge, skills and abilities required for ship engineers as listed at "The Occupational Information Network" and (3)the knowledge areas specified in "Project Management Body of Knowledge" guide have been examined. The results revealed that there has been positive impact of PBL on the graduates during their work life.

Keywords: *Project Based Learning, SolarSplash, Green Energy, Marine Engineering*

1. INTRODUCTION

The recent trends in the world of professional work as well as the academic world demand that the under graduate, when having completed higher education, have been equipped with general intellectual abilities and perspectives, higher order cognitive abilities and general personal competencies to be activated at interpersonal relations, getting involved in teamwork, problem-solving, decision-making, effective communication and leadership[1].As students learn better and easier by actively participating in the learning process, student-centered learning and teaching environment in engineering programs have become more and more common in higher education. Team project-based learning has been introduced and is increasingly used as a teaching and learning method in higher education to promote knowledge building through social interaction [2].

As the dynamics of working environment change, education and training methodologies that prepare students for real life have to change and adapt themselves. Feller explained the differences between the old and new paradigm of teaching (See Table1). In the new paradigm students are involved in construction of the knowledge, the aim of the instructor is to develop students' competencies and talents rather than to classify and sort students and cooperative learning is applied instead of competitive learning, instead of transferring knowledge from faculty to student, knowledge is jointly constructed.

Table 1Theold and new paradigm of teaching

	Old paradigm	New paradigm
Knowledge	Transferred from faculty to students	Jointly constructed by students and faculty
Students	Passive vessels to be filled by faculty's knowledge	Active constructor, discoverer transformer of own knowledge
Faculty purpose	Classify and sort students	Develop student's competencies and talents
Relationships	Impersonal relationship among students and between faculty and students	Personal transaction among students and between faculty and students
Context	Competitive /individualistic	Cooperative learning in classroom and cooperative teams among faculty
Assumption	Any expert can teach	Teaching is complex and requires considerable training

Source: (Fellers, 1996) [3]

2. ACTIVE LEARNING IN DEUMF

Maritime transportation is a complex and dynamic socio-technical system formed by technology, environment, people and organizational structures.

In this multi-dimensional, multi-disciplinary and dynamic environment, the aim of maritime education and training is not only to give trainees basic technical knowledge to perform pre-designed routine and standardized objectives, but also to improve their critical

thinking, decision-making and problem-solving skills, social intelligence and moral motivation[4].Maritime education has to focus more on team-spirits, group success, asense of collaboration, becoming involved with and helping one another[1].

Student-centered active learning methods have been used at DEU Maritime Faculty since 2002, including miscellaneous methods ranging from problem-based learning to task-based learning.The education strategy of Maritime Faculty is to empower students and to provide the students with certain proper knowledge, supported by desired skills and profound attitudes that they will need in their future professional careers and also give them the ability to respond quickly to changes in technology, operations, practices and procedures on board and ashore. DEUMF accepts active learning as a valuable and reliable method to achieve these aims and to comply with the requirements of STCW/78 and 2010 Manila amendments.

Project Based Learning (PBL) isa systematic teaching method that engages students in learning essential knowledge and life-enhancing skills through an extended, student-influenced inquiry process structured around complex, authentic questions and carefully designed products and tasks [5]. Shortly we can definePBL as a model that organizes learning around projects. PBL not only enhanceslong-term retention of knowledge but improves non-technical skills of students.

Projects are complex tasks, based on challenging questions or problems, that involve students in design, problem-solving, decision making or investigative activities; give students the opportunity to work relativel yautonomously over extended periods of time; and culminate in realistic products or presentations[6]. PBL can cover a spectrum ranging from brief projects based on a single subject to year-long and multidisciplinary projects. The projects are specifically designed to cover situations that are typically encountered in the world of shipping industry and to raise students' awareness of the application of managerial principles to industrial and commercial problems. The overall aim is to simulate situations that require solutions by small project teams [7].

The graduates of the Marine Engineering Department are employed as officers on board merchant vessels, in charge of supervising and coordinating the activities engaged in operating and maintaining engines, boilers, deck machinery and electrical and refrigeration equipment. Different forms of active learning have been applied and experienced at DEUMF Marine Engineering Department to improve the quality of higher education. The first-year students are exposed to 11 modules through Problem Based Learning methodology, three of which cover department specific subjects and the others are on the basic engineering programs studied in collaboration with DEU Faculty of Engineering. The second and third-year curricula are mainly designed around modules based on marine engineering subsystem. The forth-year curriculum is designed on Task-Based Learning approach and covers such eight blocks as Technical Ship Management, Engine Room Simulator at management level, Main and Auxiliary Machinery Operations and Maintenance, Refrigeration and HVAC Systems, Technical and Operational Ship Management, Engine Room Simulator Advanced Skills, Safety at Sea and Emergency Operations, and Hydraulic and Pneumatic Control System.

3. EFFECTIVENESS OF PBL

There has been an ongoing debate about the effectiveness of active learning methods. There are many ways of making judgments about the effectiveness of active learning and especially within the content of this study Project-Based Learning. This study is based on the survey method and participant self-report to evaluate PBL effectiveness. A follow-up study has been conducted on project team members who have been working on board of merchant for two years as officer. The impacts and effectiveness of Project Based Learning on (1) the programme out comes of Marine Engineering Department, (2)the knowledge, skills and abilities required for ship engineers and listed in "The Occupational Information Network" and (3)the knowledge areas specified in "Project Management Body of Knowledge Guide" have been examined. The instruments used in collecting data are open–ended as well as Likert type survey questionnaire. The details of these measurement tools are mentioned below.

The main objective of the Bologna Process is to ensure more comparable, compatible and coherent systems of higher education in Europe. The Ministers responsible for higher education in the forty-six countries of the Bologna Process convened in Leuven/Louvain-la-Neuve in 2009 and determined higher education priorities for the decade to come. These priorities and main working areas for the next decade were social dimension, lifelong learning, employability, student-centred learning and the teaching mission of education, international openness, mobility, education, research and innovation, as well as data collection, funding of the Higher education and multidimensional transparency tools[8].

Within the Bologna Process DEUMF Marine Engineering Department defined 20 programme outcomes by a participative process (See Table 2). Programme outcomes can be defined as "what the student is expected to know, understand and be able to do immediately after graduation".

The O*NET program is a source of occupational information. Central to the project is the O*NET database, containing information on hundreds of standardized and occupation-specific descriptors. The database, which is available to the public at no cost, is continually updated by surveying a broad range of workers from each occupation [9].The Content Model which is the conceptual foundation of O*NET provides a framework that identifies the most important types of information about work and integrates them into a theoretically and empirically sound system.

Table2.Marine engineering program outcomes

PO1:An ability to apply knowledge of mathematics, science and engineering to marine engineering problems

PO2:An ability to identify, formulate and solve engineering problems in marine engineering and related fields
PO3:An ability to design a system, component or process to meet desired needs
PO4:The broad education necessary to understand the impact of marine engineering solutions, especially related to the maritime safety, health, maritime security and marine environmental issues in a global and social context
PO5:An ability to analyze and interpret marine engineering related data, as well as to design and conduct experimental work if necessary
PO6:An ability to use the techniques, skills and modern engineering and computing tools necessary for marine engineering practice
PO7:An ability to function on same and multi-disciplinary teams
PO8:An ability to function independently
PO9:A recognition of the need for, and an ability to engage in life-long learning
PO10:An ability to communicate effectively orally and in writing in Maritime English/Turkish
PO11:An understanding of professional and ethical responsibility
PO12: Knowledge of contemporary issues
PO13: Knowledge and awareness of quality issues
PO14:The broad education necessary to perform marine engineering at operational/management level
PO15:The broad education necessary to perform electrical, electronics and control engineering at operational/management levels
PO16:The broad education necessary to perform maintenance and repair at operational/management levels
PO17:The broad education necessary to perform controlling the operation of the ship and the care for person at operational/management levels
PO18:An ability of leadership and managerial skills
PO19:Commitment to Turkish Maritime traditions
PO20: Knowledge of national and international legislation

The Content Model was developed using research on job and organizational analysis. It embodies a view that reflects the character of occupations (via job-oriented descriptors) and people (via worker-oriented descriptors). The Content Model also allows occupational information to be applied across jobs, sectors or industries (cross-occupational descriptors) and within occupations (occupational-specific descriptors). These descriptors are organized into six major domains, which enable the user to focus on areas of information that specify the key attributes and characteristics of workers and occupations. These domains are: Worker Characteristics, Worker Requirements, Experience Requirements, Occupation-Specific Information, Workforce Characteristics and Occupational Requirements [9].Within the content of this study, Knowledge, Abilities, Skills required for a Ship Engineer were used during the survey. According to the definition as mentioned at O*NET, Ship Engineers supervise and coordinate activities of crew engaged in operating and maintaining engines, boilers, deck machinery and electrical, sanitary and refrigeration equipment aboard ship.Project management has become an important area of study among engineering students. A Guide to the Project Management Body of Knowledge (PMBOK Guide) defines the term project as a "temporary endeavor undertaken to create a unique product, service or result" and defines "project management" as the "application of knowledge, skills, tools and techniques to project activities to meet project requirements".PMBOK Guideis a recognized standard for the project management profession and a formal document that describes established norms, methods, processes, and practices for managing most projects, most of the time across many types of industries[10]. International Project Management Association (IPMA) states: "Project Management (PM) is the planning, organising, monitoring and controlling of all aspects of a project and the management and leadership of all involved to achieve the project objectives safely and within agreed criteria for time, cost, scope and performance/quality[11].

PMBOK Guide identifies nine Knowledge Areas that project managers should focus on while managing projects during the project life. These nine know ledgeareas are described below according to PMBOK Guide[10]. Zwikael [12]revealed that the knowledge areas with the greatest impact on project success were time, risk, scope and human resources.

1) Project Integration Management includes the processes and activities needed to identify, define, combine, unify and coordinate the various processes and project management activities within the Project Management Process Groups. In the project management context, integration includes characteristics of unification, consolidation, articulation and integrative actions that are crucial to project completion, successfully managing stakeholder expectations and meeting requirements. Project Integration Management entails making choices about resource allocation, making trade-offs among competing objectives and alternatives and managing the interdependencies among the project management Knowledge Areas.

2) Project Scope Management includes the processes required to ensure that the project includes all the work required and only the work required to complete the project successfully. Managing the project scope is primarily concerned with defining and controlling what is and is not included in the Project.

3) Project Time Management includes the processes required to manage timely completion of the Project.

4) Project Cost Management includes the processes involved in estimating, budgeting and controlling costs so that the project can be completed within the approved budget.

5) Project Quality Management includes the processes and activities of the performing organization that determine quality policies, objectives and responsibilities

so that the project will satisfy the needs for which it was undertaken.

6) Project Human Resource Management includes the processes that organize, manage and lead the Project team.

7) Project Communications Management includes the processes required to ensure timely and appropriate generation, collection, distribution, storage, retrieval and ultimate disposition of project information.

8) Project Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning and monitoring and control on a project. The objectives of Project Risk Management are to increase the probability and impact of positive events and decrease the probability and impact of negative events in the project.

9) Project Procurement Management includes the processes necessary to purchase or acquire products, services or results needed from outside the project team.

4. SOLAR SPLASH PROJECT

In 2009, Green Energy Projects Office (GEPO) was established at DEUMF to promote student projects related to solar, wind and hydrogen energy. The first project within this office was to design and build a solar boat and to join the Solar Splash races which have been organized for 18 years in USA. Solar Splash races began in Milwaukee, Wisconsin, in 1994, hosted by Marquette University. In 2000 it was moved to New Orleans to drum up interest from more southern teams and then to Buffalo, New York, from 2001-2005. Solar Splash was held in Fayetteville, Arkansas on Lake Fayetteville from 2006-2010. The event has been hosted by the University of Northern Iowa in Cedar Fall, Iowa, from 2011[13]. Solar Splash is the World Championship of intercollegiate Solar/Electric boating. Its official name is "an international intercollegiate solar/electric boat regatta" and it takes place forover five days. Technical Inspections are done on the first day and the remainder of the time is occupied by five on-the-water competitive events. Points are earned in 7 categories starting with Technical reports that are submitted before teams arrive at the competition. On-site competitions include Visual Displays and Workmanship. On-the-water events begin with a Sprint and a Maneuverability qualifier. This is followed by an event called the Solar Slalom, which is a combination of speed and maneuverability. The final days are spent in the Sprint and Endurance events [14].

Table 3Thespecifications of DEU solar boat

	Endurance	Sprint
Length	5,25 m	5,25 m
Length (include shaft)	5,95 m	5,95 m
Beam	1,17 m	1,17 m
Depth	0,52 m	0,52 m
Draft	0,15 m	0,16 m
Weight	222,7 kg	230,kg
Motor Power	2.2 kW	7 kW
Motor RPM	650	1000
Propeller RPM	720	3071
App. Solar Array Output	450 Watt	-
Batteries	2 x 42 Ah Lead Acid Battery	3 x 44 Ah Lead Acid Battery
Maximum Current Draw	70 A	245 A
Maximum Speed	6 knots	18 knots

According to the technical specifications mentioned in the rules prepared by the Solar Splash organization, DokuzEylul University Solar Boat Team built their composite boat by using aramid fiber and epoxy resin with the specs given in Table 3. During the building stage of the solar boat approximately more than 20 students from different classes from DEUMF got involved in the project. 9 students and 3 advisor academics attended the events held in IOWA in 2011. It took 3 years to finish building the boat including the design stage. An interdisciplinary group of advisors consisting of a naval architect and a marine engineer, a mechanical engineer and an electronics engineer also supported the project. Technical and financial support has been gained by the students from various regional industries. Some of these companies sponsored the project.

A team of 9 students consisting of 7 senior students, 1 sophomore and 1 freshman students participated in this contest and got the 7th rank, Rookie Team, with highest overall score and outstanding drive train design awards.

5. AIM OF THE STUDY

There has been an ongoing debate about the effectiveness of active learning methods and the number of researches related to the transfer of the skills and knowledge gained by these methods to real life is limited in the literature. This study is aimed at making a contribution to that area.

A follow-up study has been conducted through project team members who had been working on board of merchant vessels two years after their graduation. There were 11 students in this class and 7 of them were reached within this study. Return rate was 63%. Participants self-report through a survey tool to evaluate PBL effectiveness approach is used to assess the effectiveness of Project-Based Learning.

A questionnaire was used to collect the data. Statements concerning the objectives of the study were developed in order to determine the attitudes of graduates towards PBL and its impact on their work life. The questionnaire has four parts. The first part which has twenty statements is to determine the impact of PBL on the programme outcomes of marine engineering department. The second part which has thirty statements, is related to the knowledge, skills and abilities required for ship engineers as listed in “The Occupational Information Network” and the third part has nine statements related to the knowledge areas specified in “Project Management Body of Knowledge”. 5-point Likert Scale with anchors at 1 (I strongly do not agree) and 5 (I strongly agree) was used in the questionnaire. At the fourth part, an open ended question was used where the respondents were allowed to write their thoughts in their own words about the contribution of being a solar

splash team member and PBL to their social and professional life.

6. FINDINGS

Some parts from students' essays for the open ended question related to the contribution of being a solar splash team member and PBL to their social and professional life are extracted below.

As I understand the importance of teamwork during the Project I easily adapted myself as a team member on board... (Member of a mechanic team)

Before entering the work life this project team improved my self confidence and improved my technical capacity and improved my ability to look at events from different perspectives… (Team Member)

*That project improved my skill to have responsibility and to achieve my responsibilities as well as possible. In my professional life this Project improves my skill to understand and realize the problem earlier and to take the precautions in time. Planning is an important skill for success on board and this project improved my planning skills. When there is any problem on plans we had skill to make corrective actions...(*Chief of Technical Team**).**

Within the scope of an engineering Project, while trying diverse and various means of dealing with the problems we have encountered, we indeed have gained precious experiences in terms of coping with both the expected and unpredictable problems, particularly managing the problem solving processes effectively. Despite various errors and failures suffered, our efforts made on the project have granted us with invaluable experiences regarding error and crisis management. Such experiences have enabled us to keep the project in operation; having utilized the written and/or live data collected through various researches and reflected it to the project. Besides, the team work and cooperation we have established has provided us with some exceptional experiences, which would otherwise be difficult through many other methods. Furthermore, certain social and interrelational gains we have been granted through such experiences have improved our team work competencies and abilities to be a part of the team acting in compliance with certain disciplinary norms to reach the targets set. Thanks to such competencies we have received in dealing with the technical problems and crises encountered in our professional life, we are better able to conduct/manage rational and solution focused efforts. Predicting the likely problems we are able to make proactive proposals. Such a competency is, of course, a very critical differentiation in favor of a marine engineer. The main source of this competency is the gains we have enjoyed during the project process…(Team Leader)

Solar Project has provided me with the competency to manage many things in a short time in terms of my professional life and taught me that in social life the team work is the most efficient means of getting the best possible success and also that team work is indispensable in this distinguished profession of marine sciences… (Member of Mechanic Team)

.I gained ability to work in multidisciplinary teams and follow new technologies... (Member of Hull Team)

The impact of Solar Splash Project on the learning outcomes of marine engineering department is mentioned below with the ones having highest overall mean scores.

An ability to design a system, component or process to meet desired needs (μ=4.2857), an ability to analyze and interpret marine engineering related data, as well as to design and conduct experimental work if necessary (μ=4.1429), an ability to function on same and multi-disciplinary teams (μ=4.1429), an ability to function independently (μ=4.4286), a recognition of the need for, and an ability to engage in life-long learning (μ=4.4286), an understanding of professional and ethical responsibility (μ=4.2857), a knowledge of contemporary issues (μ=4.0000), the broad education necessary to perform maintenance and repair at operational/management levels (μ=4.000), the broad education necessary to perform controlling the operation of the ship and the care for person at operational/management levels (μ=4.1429) an ability of leadership and managerial skills (μ=4.1429).Considering O*NET, knowledge, skill and abilities required for ship engineers are mentioned below with the ones having highest overall mean scores. Considering knowledge: design (μ= 4.5714),administration and management (μ=4.3333), mechanical (μ=4.2857). (See Table 4)

Table 4 Impact of PBL on knowledge

Knowledge	N	Mean
Mechanical	7	4.2857
Public Safety and Security	7	3.5714
Engineering and Technology	7	4.1429
Transportation	7	3.2857
Mathematics	7	3.0000
Law and Government	7	3.5714
Education and Training	7	4.0000
Design	7	4.5714
Administration and Management	7	4.3333
Computers and Electronics	7	4.0000

Considering skills: monitoring(μ=4.7143), operation monitoring(μ=4.5714), troubleshooting (μ=4.5714),repairing (μ= 4.5714),active listening (n: 4.4286), equipment maintenance(μ=4.2857), operation and control (μ=4.2857),speaking (μ=4.4286) have highest mean values. (See Table 5)

Table 5 Impact of PBL on skills

Skills	N	Mean
Critical Thinking	7	3.8571
Active Listening	7	4.4286
Equipment Maintenance	7	4.2857

Troubleshooting	7	4.5714
Monitoring	7	4.7143
Operation Monitoring	7	4.5714
Operation and Control	7	4.2857
Quality Control Analysis	7	4.0000
Repairing	7	4.5714
Speaking	7	4.4286

Considering abilities: deductive reasoning (μ=4.571), oral comprehension (μ=4.2857), Speech Clarity (μ=4.2857),written Comprehension μ=4.4286) have highest mean values(See Table 6).

Impact of Solar Splash Project on Project management knowledge areas are found as follows, with highest mean scores: project time management(μ=4.5714), project human resource management(μ=4.4286), project communications management(μ=4.4286). (See Table 7)

Table 6 Impact of PBL on abilities

Abilities	N	Mean
Problem Sensitivity	7	4.1429
Oral Comprehension	7	4.2857
Oral Expression	7	4.1429
Control Precision	7	3.8571
Near Vision	7	4.0000
Speech Clarity	7	4.2857
Arm-Hand Steadiness	7	3.7143
Speech Recognition	7	4.1429
Written Comprehension	7	4.4286
Deductive Reasoning	7	4.571

Table7 Impact of PBL on PM knowledge areas

PM knowledge areas	N	Mean
Project Integration Management	7	4.1429
Project Scope Management:	7	3.8571
Project Time Management	7	4.5714
Project Cost Management	7	4.2857
Project Quality Management	7	3.4286
Project Human Resource Management	7	4.4286
Project Communications Management	7	4.4286
Project Risk Management	7	4.1429
Project Procurement Management	7	4.2857

7. CONCLUSIONS

The results of the follow up study that was conducted through solar splash project team members two years after their graduation revealed that PBL has improved graduates'self confidence and technical capacity, lifelong learning, administration and management knowledge, deductive reasoning abilities and trouble shooting skills and ability to function on same and multi-disciplinary teams. It is concluded that PBL approach has positive impact on the graduates during their professional careers.

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