INDUSTRY BASED SHIP DESIGN PROJECT FOR NAVAL ARCHITECTURE STUDENTS

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ÖZET

Türk gemi inşaatı endüstrisi, 2000'lerin başından bu yana dünya ile rekabetini arttırabilmek için katma değeri yüksek gemi tiplerinin yapmayı amaçlamıştır. Rekabeti arttıra bilmek için verimlilik, kalite, zamanında teslim, ileri tasarım ve üretim yöntemleri daha da fazla önem kazanmıştır. Gemi Mühendisliği öğrencilerinin ulusal ve uluslararası gelişmeleri takip etmeleri gerekmektedir. İstanbul Teknik Üniversitesi (İTÜ), Mühendislik ve Teknoloji Akreditasyon Kurumuna (Accreditation Board for Engineering and Technology-ABET) eğitim kalitesini tescillemek amacı ile başvurmuş ve 2003 senesinde akredite olmuştur. ABET eğitim kalitesini yükseltmek için takım çalışması, yazılı ve sözlü sunum becerilerinin arttırılması vs. gibi tavsiyelerde bulunmuştur. Bu kapsamda İTÜ Gemi İnşaat ve Gemi Makinaları Bölümü, Gemi İnşaatı Proje Dersinin içeriğini yeniden düzenleme kararı almıştır. Bu sistem 2005'den bu yana uygulanmakta olup, başarısı endüstri tarafında da onaylanmıştır. Bu sistem öğrenci ve akademisyenlerin grup çalışması yanı sıra endüstrinin de desteği ve öğrenci-akademisyen-tasarımcı üçlemesini koordinasyon ve iş birliği le devam etmektedir.

Keywords: Naval architecture; education; industrial-based.

1. Introduction

Istanbul Technical University (ITU) applied to The Accreditation Board for Engineering and Technology (ABET) for "continuous quality development" and fourteen (http://www.abet.org/global-presence/substantial-equivalency-2/) departments, including The Department of Naval Architecture and Marine Engineering (NAME), were accredited by ABET in 2003. Accordingly, the department adopted recommendations of ABET in its curriculum. Criteria of ABET includes an ability to utilize mathematics, physics and engineering knowledge to solve engineering problems, to be able to work in a multi discipline team, an ability to design a system or an artifact, to take ethical responsibility, refreshment of knowledge, an ability to utilize modern problem solving techniques etc.

Many engineering faculties attempt to teach engineering design often through compulsory programs such as final year projects etc., (Ratnajeevan, 1991). On the other hand, most universities use the modular course approach, where if a student does not use new knowledge then he/she tends to forget it. To eliminate this retention problem most modular universities have a capstone design course in their final undergraduate year for the purpose of refreshing forgotten knowledge by its use and to integrate all the previously attained knowledge ((Lamb and Cooper, 2006). In the Department of Naval Architecture and Marine Engineering at ITU, design topic is taught during ship design project (SDP) course during two semesters through team work by the support industry since 2005. Prior to this date it was taught in two semesters, but neither supported by team work nor by industry contribution.

Engineering is composed of system and object buildings, the essence of which is called as "design". The very basic engineering characteristics are the creative synthesis of new systems and components; hence design is the heart of engineering. During such a process experience is an important component of engineering design and education. Therefore, the education of an engineer is not complete until he/she goes to the industry (Ratnajeevan, 1991). Design is one of the most important subjects in engineering education and it requires experience and lecturers are usually not very well equipped for this. Industry based design teaching is necessary for a good engineering education.

There will be substantial changes in educational content and structure as the profession develops (Woods, 2006). Engineering education is becoming more and more important as well as challenging. Several universities have been working to improve their education systems (Woods, 2006, Woud et al., 2006, etc.). Some universities have aimed to prepare their students for "the real world", which is full of inconsistencies, complex, and changes all the time. The real world also involves participants from different domains with political and cultural aspects. To meet this challenge, a project based on real examples from industry may be done, or obstacles and dirty tricks in student exercises may be introduced (van Vliet, 2005).

It is always necessary to investigate and adopt the impact of new technologies on the education system with educational training and professional development meeting the changing needs of the industry (Woud et al., 2006). A university continuously learns and transforms itself to respond and adapt to changing environmental conditions (Psarianos, 2006).

Today, another challenge of engineering education is weak relations between universities and industry, where it is important to improve communication and representation skills. Most of the American and Canadian schools require a course in technical communication, because many organizations fail to communicate effectively (Ales and Tuttle, 2006). It is frequently believed that the most important communication line is associated with the company customers. Nevertheless, the internal communication of a company departments, divisions or employees will enable the effective and efficient production of goods or services (Psarianos, 2006). The work as a team in SDP improves students and lecturers communication skills. On the other hand, lecturers and students work with people from real design offices and have to communicate with them as well.

Turkish industry relied on technology transfer from foreign companies rather than on domestic technology development (Tantekin-Ersolmaz et al., 2006). Hence, the new system helps to improve the current technology, because of close relationship among designers-students-lecturers.

The learner may in no case be excluded from the 'learning contract' (Psarianos, A., 2006). Before the young naval architects start to work, they start to communicate with the designers for a chance to learn from each other.
Teaching in the engineering science is often easier than in design, and is closer to faculty research interests, requires less engineering experience, and can be performed without time consuming contacts with industry (Jones, 1991). It is aimed to overcome such problems as the new system helps the faculty members to improve their teaching skills in design.

As a result of the above mentioned reasons, The Department of NAME decided to change the education system step by step. The first step includes "Ship Design Project" (SDP) lectures, where the main principle of the new system is to simulate a design office as close as possible. It was decided that students and lecturers should work together in teams. On the other hand, teams of students would have a partner such as a design office to promote their projects. Every team would be as large as 4 or 5 students from different success levels.

The aim of this paper is to present a new system on SDP lectures and to prove that it is extremely useful. The three-year period experience on the lectures demonstrates that the system is valuable and could be more effective in some circumstances. The importance of design teaching is explained together with the developments from the previous beneficial systematic works.

2. Team Work

The team work principle for SDP lectures includes the student effort conducted in teams, however teamwork has been extended into collaborative work of student with the lecturers and the designer from the industry. Before new system was introduced, every student was working with one of the lecturers, however both sides could not choose each other and students could not be in contact with other lecturers as shown in Figure 1a. This simple system is based on the student skills and the lecturer knowledge. Team work communication diagram represents the relationship between the teams and the designers and Figure 1b shows the important changes by team work and industrial based design teaching.

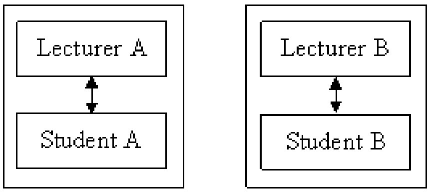

Figure 1a. Old system for SDP

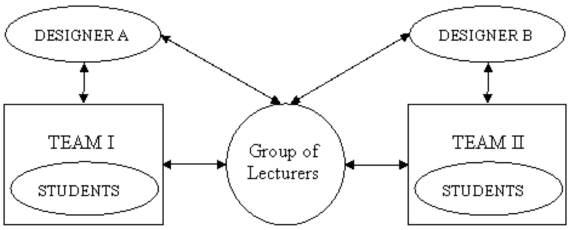

Figure 1b. New system for SDP

2.1 Team of Students - Team of Lecturers

There are some skills that every engineer should gain as two of them are given s follows: (Unsan et al., 2006):

- To understand, formulate and solve an engineering problem, and
- To work in a team successfully in a hierarchy,

During their engineering education, students have some opportunities to work in project groupsbut in this case, they must work together as well as getting instructions from designer and lectures to fill the gaps in their projects. On the other hand, groups are restricted by rules which are explained in Section Team Work Principles.

The following profits are expected to achieve in such a team work (Unsan et al., 2006):

- Development of the relationship between lecturers and students,
- To work with other students who may not be accustomed to communicate before the lecture or project team,
- To develop some student skills such as problem solving and decision making,
- To develop curiosity and desire to learn,
- To develop communication skills,
- To understand professional life or real world from the designers,
- To understand, to gain the ability to manage and work under management.

This is a very difficult task for students at the beginning but the benefits are worth of it. The more heterogeneous is the groups, the better the student work is in the group, which should be more than "providing experience." It implies that the student should learn beyond his/her experience by working in groups so that he/she is prepared better to plan and contribute to group work (Jones, 1991). Despite the initial resistance from the students at ITU the groups are established as heterogeneous as possible and as a consequence, they carried out their work successfully except a few groups.

2.2 Team of Lecturers

Every lecturer at the department teaches one or more subject individually, and usually they teach the same subjects over the years. In SDP, lecturers attend the class together and have a chance to examine each other's work. On the other hand, they communicate with designers concerning the students' projects. Designers and lecturers can observe the technological gaps between the universities and the industry with understanding the significance of joint work to close the project gaps.

The success of many aspects in engineering education generates complacency and increases resistance to changes in design where failure is evident. Advancing the frontiers of engineering education requires improving design education.

2.3 Support from Designers

Designers and shipyards in Turkey have been working overloaded for the last few years. They have been seeking for talented and experienced naval architects. The first year ship design project lecture gathered a set of designers to discuss the lecture layout, ask their opinion about the system, and whether they were eager to collaborate. They were excited and became enthusiastic about the work project with young naval architects. However, during the semester they sometimes found it difficult to have spare time to communicate with lecturers and students in sharing their time and knowledge. Some experienced naval architects attended lectures regularly from the industry for the improvement of the students' communication skills and their self-confidence.

2.4 Team Work Principles

The National Academy of Engineering and ABET committees with other governing engineering education bodies around the world required that an actual design example should be included in the engineering education. In the last decade focus on design experience had impacts on teaching teams, teamwork and on the student teams in developing their designs (Lamb and Cooper, 2006).

Team work with student aims to simulate a project office environment and to fulfill ABET requirements. In an office, everybody is different and nobody can choose his\her office mate. The employees of an office should deal with difficult situations with solutions in a positive way that is exactly what one expects from the students. In this manner the team rules and a ship design project development are set in advance (http://www.gidb.itu.edu.tr/staff/projedersi/index.htm). Every team has 4 or 5 students from different levels ranging from the best to the worst. It is rather difficult for somebody to change his/her team, but still it is allowed within the first four weeks. However, a new employee cannot change his/her job because of the contracts made until the end of project. It is important to remember that the students should abide by the strict professional life rules.

Every group should have a leader, secretary and controller. The leader and the other members of the team have the same responsibility in the project. Leadership concept in the team helps students to improve their management abilities. The members share the parts of the project, but at the end, everybody should know all the details of the project. They have to teach each other and improve their knowledge collectively. If one of the members lags behind the team work then he/she should be graded as "unsuccessful".

The contents of ship design project are prepared according to team work of students by taking into account the support of industry. Each member gets marks from technical project and team work. In any semester, every team submits 4 technical reports about the work.

At the end, each project is presented by team members in front of lecturers, designers and the members from the industry. They are asked questions about their technical work by the audience in the room. The team should prove that their project is properly done and producible.

3. Case Study

SDP lecture system was changed in 2005. There was a resistance from the students and the lecturers at the beginning. Students resisted because they did not want to work together with other students who they did not know before. Lecturers resisted because it seemed time and energy consuming in addition to more communication activity with other lecturers and therefore, they insisted that it might not work properly. On the contrary, the department decided to go forward and set the program. Most of the department members were involved in the program. A commission prepared the rules to make up a team and technical details, which were included in the projects.

Consistent with work principles, teams are arranged by taking into account average marks and the students' settlements in town. Average marks and the number of team members are given in Table 1 to show the heterogeneity of the teams. The number of teams and designers were decided and then a meeting with designers was arranged about the ship types and how they could support their teams. The ship types between 2005 and 2007 are given in Table 2. Some of the ship types have not been worked on before, the revision such as motor yacht, sailing yacht, landing craft etc.

Some students with low mark have showed very good performance during their work and became team leaders. Contrarily, some good students with high marks have not managed to become a team member. In three years, only a few teams have changed the members because they could not work together.

SDP lectures also are supported by some seminars in the area experts such as in the topic of rules and regulations from the maritime administration.

Table 1. Average marks and numbers of each team

2006-2007 Ship Design Projects		
Team No	**Number of team members**	**Average marks of students out of 4 full mark**
1	5	1.94, 2.21, 2.24, 2.45, 2.77
2	5	1.76, 1.83, 2.14, 2.49, 2.67
3	5	1.85, 2.05, 2.14, 2.31, 2.97
4	5	1.93, 2.13, 2.22, 2.52, 2.87
5	5	1.41, 2.30, 2.32, 2.55, 2.72
6	5	1.55, 1.88, 2.22, 2.25, 2.94
7	4	1.97, 2.15, 2.16, 2.90
8	5	2.04, 2.16, 2.32, 2.53, 3.16
9	4	1.96, 1.99, 2.08, 2.44

The objectives of most final year capstone design courses for The North America are given in Table 3 (Lamb and Cooper, 2006). Also the comparison of the old and new systems at ITU according to the objectives of The North America is represented in Table 3.

In Table 4 the skills gained during the project stage are represented as well as the subjects carried out at the different design stages for the old and the new systems. Tables 3 and 4 demonstrate that team work industry based design projects change the scope of students and the industry in a very positive way.

Every semester some teams presented productive works. The best work of 2005-2006 academic year is shown in Figure 1. Instead of preparing very limited projects on their own, the students became able to design very detailed projects and understand what they are involved with.

The final exams are carried out in front of a jury including designers and lecturers, to improve the communication skills, presentation skills and self-confidence of the students. Students had to present their work including the weak points of their projects. They also have to pass a written exam to prove their understanding of the project.

Table 2. Ship types of the last 3 years

	2005 (7 teams)	**2006 (9 teams)**	**2007 (7 teams)**
SHIP TYPES	28 m Fishing Vessel	Fishing Vessel	20 m CAT Fishing Vessel
	1600 TEU Container Ship		900 TEU Container Ship
	50 m Motor Yacht	45 m Motor Yacht	36 m Sailing Yacht
		8300 m^3 Gas Carrier	
	3300 DWT Tanker	4600 DWT IMO II Chemical Tanker	
	Landing Craft		
		6000 DWT Cargo Ship	
		3500 DWT General Cargo Ship	5600 DWT General Cargo
		11000 DWT Chemical Tanker	8500 DWT IMO II Chemical Tanker
	Cement Carrier		
		3150 DWT Bunkering Tanker	

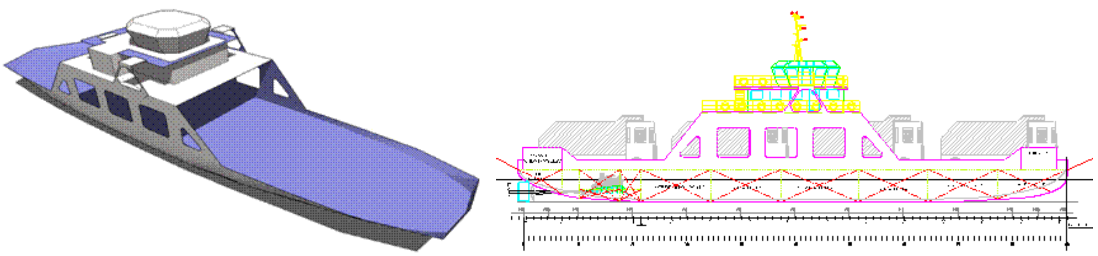

Figure 1 The best project in 2005

Table 3. Comparison of the old and new systems at ITU with The North American System

Objectives of The North American System	Old System at ITU	New System at ITU
To provide senior students with the opportunity to apply the knowledge learned from academic courses leading up to the capstone design course	Partly, because only one lecturer was advising the student during project.	Fully, because most of the lecturers are attending the project and advising the students with designers
To introduce students the current design tools used by industry	Partly	Mostly
Further developed design skills and strengthen problem solving skills	Partly	Mostly, because of team work and the designer help
Developed written and oral communication skills	No presentation and proper document representation was compulsory	Presentation and full document representation is compulsory
Interact with engineers in the marine industry and gain exposure to contemporary engineering practices	Not applied or depend on the lecturer	Fully applied, because teams work with a design office
Give industry the opportunity to inference with students and faculty in a design project environment, and thus influence the outcome of the course	Not applied	Applied
Work in a team to design a marine system	Not applied	Applied
To provide senior students with the opportunity to apply the knowledge learned from academic courses leading up to the capstone design course	Partly, because only one lecturer was advising the student during project.	Fully, because most of the lecturers are attending the project and advising the students with designers

Table 4. Comparison of the skills and the knowledge gained from the old and the new systems

Design Stage and Skills	Subject	Old System	New System
Concept Design	Concept design process	Partly applied	Applied
Preliminary Design	General arrangement plans	√	√
	Preliminary design calculations	√	√
	Request for proposal		√
	Ship lines plan	√	√
	Hydrostatic calculations and diagrams	√	√
	Stability calculations and curves	√	√
	Damage stability		Partly applied
	Powering calculations and selection of main engine	√	√
	Longitudinal strength calculations	√	√ (n/a for small vessels)
	Trim calculations and diagrams	√	√
	Constructional details of mid-ship section	√	√
	Longitudinal section	√	√
	Shell expansion	√	√
	Freeboard calculations	√	√
	Propeller design and arrangement	√	√
	Rudder design	√	√ (more detailed)
	Sea-keeping and manoeuring		√
	Engine room arrangement	√	√
	Piping arrangement	√	√ (more detailed)
	Electrical systems	Partly or not applied	Partly applied
	Vibration		√
	Draft ship building contract		√
Skills Gained	Communication		√
	Presentation		√
	Negotiation		√
	Analysis and Synthesis	Partly or not applied	Applied
	Concept design process	Partly applied	Applied

4. CONCLUSIONS

Industry based ship design projects lecture was started three years ago and the success of the new approach has been observed. Team work and close relations of designers-students-lecturers have helped to improve the quality of design projects, students' understanding about the design and especially concept design of their ships. Communication skills of designers-students-lecturers have also improved tremendously.

Academics and designers should believe and trust the benefits of team work with students. But students, younger generation, found it more difficult to understand the idea behind team work, but more enthusiastic at the work than the lecturers and the designers. A mix of different levels of experience and age has resulted in better designs.

The shortcoming of the new system is that the designers have been working overloaded and have virtually very short time to guide a group of students. There has been some lack of guidance from the designers due to time management. However, some designers have utilized this course to recruit new staff for their office. Some other designers have marketed the project resultant designs to the industry by sharing IPR with students.

Also the lecturers have to spend more time on the projects in order to follow closely all of the teams every week. On the other hand, lecturers have to find out the knowledge for different ship types that they have not worked on before. Nevertheless, different ship types are included according to the new system and the knowledge is gained both by students and lecturers.

Interchange of knowledge between students, designer and lecturers also presented a challenge as each participant has used different software for each task. No restriction has been imposed on the use of software, and hardcopy printouts or onscreen presentations have been used for the reviews of the project to overcome this problem.

Such joint works should provide challenge for students, lecturers and designers. For example, the best team and the designer could be publicized and the projects could be exposed in an exhibition. Also the knowledge gained during the projects could be published as departmental activity.

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