DEVELOPMENT OF A COURSE ON 'INTRODUCTION TO ENGINEERING' AT PIRI REIS UNIVERSITY

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Abstract: *Education in general and engineering education in particular, changed a lot during the last century. A key date in the west is Sputnik or the beginning of the space race. However the change resulting from this race did not stop but accelerated mainly with the help of the revolutionary changes in the information technology. The paper reviews some of the changes in engineering and specifically in the education naval architecture in North America. The major points of change are summarized for this field for the undergraduate education. As an example of a change the development of a course that started in Canada at the University of British Columbia and recently introduced in Piri Reis University is explained in some detail. The course content, the projects used to introduce team work and creativity and production oriented teaching are explained in detail. Modifications made to the original course and lessons learned in Piri Reis are also included. We also believe that this is the type of a course needed to introduce and explain the emerging engineering work environment.*
Key-words: *Engineering Education, Project Based teaching, Student projects*

1. INTRODUCTION

The engineering professions, and also engineering education, have been changing rapidly. At present, few theories exist on how the changes to the profession should be handled in terms of modifying the engineering undergraduate curriculum. This paper reviews the experience gained from the implementation of a project based, design-build, undergraduate course given in the last three years at Piri Reis University, Engineering Faculty, Department of Naval Architecture and Marine Engineering. Changes in engineering education are not new; they have occurred before in North America. The name of a small Soviet satellite, Sputnik, is usually associated with the beginning of these changes. Sputnik is credited with bringing about the changes to the engineering curriculum in the late 1950s and early 1960s. A large number of courses in mathematics, science and advanced engineering were added to the undergraduate engineering curricula of that time. Aerospace departments became very popular as well. Many of the professors now teaching engineering in North America were educated with and inherited that curriculum.

However, if we stop to think about it, other "machines" have also changed the world in the past, and with it, engineering. The internal combustion engine, the camera, and the computer have brought about extensive changes in our lives and also in the field of engineering. Each of these machines has changed our expectations and also the quality of life on earth.

We can try to determine what those additional dimensions are. Design methodologies and codes did not change a lot. Engineers are now expected to be more flexible, to be team players, and to be more creative and synthesis oriented. They are also expected to have more skills. Knowing specific design procedures and the codes are no longer sufficient, as both can easily be programmed or computerized. It is not enough to know how to select a pump and do the pipe head-loss calculations as an engineer, as this type of selection and calculations are relatively easily available in a small computer package.

The equations used in engineering and engineering methodology have, however, not changed much over time. We still use force equals mass times acceleration, or Newtonian mechanics. Even the large systems of equations which we now use easily, were known earlier. Companies such as Messerschmidt, the German airplane manufacturer, was said to have had, in the 1930s, six women whose job it was to invert a 6 by 6 matrix for the design of airplane wing profiles, a task which required a day to complete. Similar positions for "matrix inverters" appear to still exist at some European universities; the current version of the job, however, seems to be to input and handle matrices properly in computers. We can thus observe that engineering tools have changed greatly over the past two decades. Some educators claim that "engineering science is dead," but this remains to be seen. New engineering products still need to be developed, such as renewable energy machines, and for these we need engineering science for modelling, research development and production.

Digital drawing equipment, including rendering for three-dimensional presentation, and "quick prototyping, 3D printing" are new engineering tools. Hand drafting is not only rare today; it is also not considered "professional" by today's standards. We are now able to do numerical rather than analytical designs, and to collect digital rather than analog signals. Changes in engineering education are also visible. Books now contain at least a CD with problem-solving software, numerical programs for engineering applications, and various animations, and they refer the reader to a web site for additional information as well. Electronic versions of books are also available. While students still prefer paper books, they are able to follow web-based lectures with colour graphics and animations using their laptops in class. Professors are able to communicate with students efficiently using computers. Classrooms have also changed; they now have computers and digital projectors, and chalk-based blackboard presentations are rare. Students seem to be more motivated seeing animations of calculations, such as the output from CFD software, visual examples that one can create using a special program. As a result, professors are now able to achieve a higher level of communication using wireless networks available on campus than was previously possible, and to try student-based teaching using case studies and project-based curricula.

In the past, in order to acquire new knowledge, students had to travel long distances. For example, Pythagoras travelled to Babylon (Baghdad) to learn how to calculate the square root of integers, and to learn "his" theorem. Most of us learned this theorem from books; we did not have to go to Baghdad. And today of course, it is possible to obtain even more extensive information using the Internet. With the availability of the Internet and e-mail, we can quickly access any information we need. A relatively new use of the Internet for delivering information that of distance education is already beginning to change the concept of the university.

2. THE GAP IN ENGINEERING EDUCATION

Most of the above observations can be seen as tangible results of the development of the computer. The results obtained by the National Society of Professional Engineers in the United States, as shown in figure 1, add a measurable result to these observations. This chart might be a good starting point for thinking about the changes which have occurred in engineering and the corresponding modifications that will have to be made in the undergraduate engineering curriculum. Except in the areas of mathematics and science, there is a definite shortfall in the readiness of new engineers.

Teamwork, leadership, and integrative thinking are not the major teaching targets in current North American undergraduate education.

3. ASSUMPTIONS AND POSSIBLE SOLUTIONS

Our assumption is that this measurable gap between value and preparedness, as seen in Figure 1, is the result of the changing expectations and practices in the engineering workplace, brought about primarily by the use of the computer. In addition, teamwork, leadership and integrative thinking are new dimensions to engineering, and appear to be important to the industry. The gap between value and preparedness is similar to the gap experienced by farmers before and after the advent of the internal combustion engine, and by painters after the invention of the camera. In the field of engineering, computers have taken the load of analysis and hand calculation off the engineers, but at the same time have brought new requirements to the profession.

Farvardin N gives the following figure in [Ulsoy (2007)] as a comparison of the expectations from a modern versus classical engineer. This he does without referring to the root of the changes.

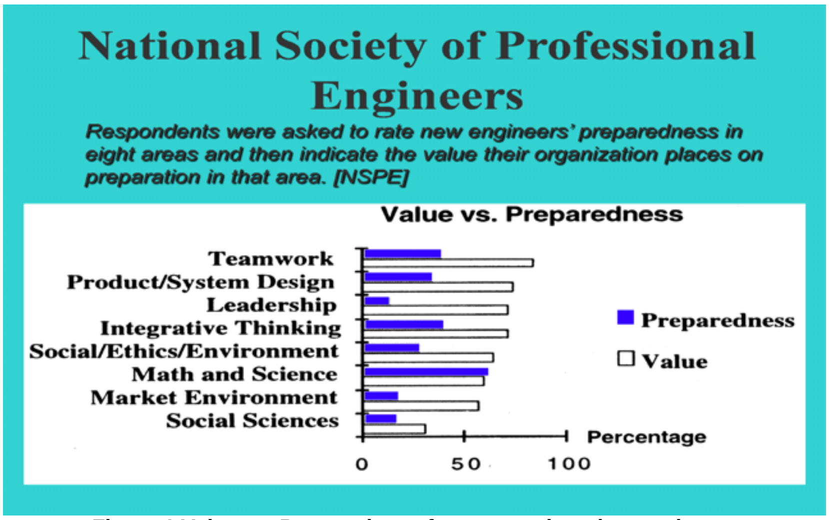

Figure 1 Value vs. Preparedness for new engineering graduates

One can speculate that engineering skills brought by computers such as CAD, FEM, CFD took space from the curriculum that was available for soft subjects such as English, psychology etc. We can conjecture that computers allow more detailed design resulting with optimization and requiring team work, possibly international in definition.

Traditional Engineer	Modern Engineer
• Problem solver	• Problem finder and solver
• Excellent mastery of technical skills	• Combines technical skills with soft skills
• Understands technical context of work	• Understand the market too
• He is content doing all her/his work in one country	• Thrives on international relations and business opportunities
• Reports up the management chain to MBA	• Hires MBA

Figure 2. Traditional versus Modern Engineer from Ulsoy 2007

One possible solution for the removal of the gap could be obtained by identifying the role of the computer in the engineering work environment and by building new curricula around this observation. The likely result of such an exercise will be the realization that undergraduate engineering education in the future will have to take place in an environment similar to that of a practicing engineer. That is to say, the type of computer support which the practicing engineer has in his workplace must also be available to the undergraduate engineering students. This has already been accomplished to some degree, as mentioned earlier, at various campuses and possibly first at the University of Michigan.

Two basic educational methods seem to exist. One is the student-centered approach, where the student is evaluated on what he has learned and not on what he does not know; and the teacher-centered approach, where the student is evaluated with quizzes and final examinations to establish the limits of his knowledge, or what he does not know.

Some educators find that teacher-centered instruction assigns a passive role to students. These educators would much rather see that a student's evaluation determine “whether a person can think in a disciplined way.” They also add that a student's abilities cannot be measured by the type of short-answer questions commonly used in quizzes and examinations.

While most educators may agree that student-centered teaching is more suitable for teaching creative work, including engineering, the main difficulty seems to be administrative. This seems to be related to the fact that the evaluation of the student's knowledge is still, in general, based on standardized tests such as the Graduate Record Examination (GRE). Standardized examinations are still the basis for acceptance of engineering students into graduate studies and into professional engineering status. This seems to form the basis of accountability of the educational procedure as far as the administration is concerned.

Other educators claim that teacher-based instruction equalizes the educational process by providing exposure to the same material to all students, and to a more organized education through an agreed-upon curriculum. In addition, teacher-centered instruction seems to be preferred by administrative organizations, as already mentioned, for the additional reasons that it is "cheaper" and more accountable, and requires fewer infrastructures such as classroom and laboratory space, educational and laboratory materials, and teacher time for projects. Student-centered education may also be at odds with the current emphasis on "accountability," which tends to focus on the educator's role and responsibility for

There are obviously other changes that need to be made in order to simulate an engineer's workplace on campus. These include providing an environment conducive to teamwork, integrative thinking and leadership training (or TIL in short). The objectives to be met are similar to those found in the teaching of team sports, and require continuous preparation and coaching, plus competitions.

Some of the results the senior author observed at the University of Michigan were most impressive. With the availability of CFD code in CAEN, referred to above, a University of Michigan fourth year student was able to calculate the three-dimensional flow around the keel of a sailboat. This was for a term paper worth twenty per cent of the course mark in an undergraduate course on sailboat design. At UBC similar attempts have been made to increase the exposure of students to various new engineering design tools in various courses. In fluid mechanics some of the concepts of CFD were introduced in undergraduate courses, and recently, a CFD laboratory content was included in the third year fluid mechanics course, using FLOWLAB software. However, we still insist on teaching many concepts requiring extensive analysis, such as boundary layer flow, in a lecture-based format. One can question whether there are more effective ways to introduce such concepts, such as with the help of computers or physical experiments. Do we really need extensive analysis such as perturbation methods at this level in order to introduce mainly concepts? To answer this question, we need to know if the engineer of the future will need to use an extensive amount of analysis or will be using a computer-based approach such as a CFD code for design. We can ask if he will be using software provided by salespeople to select fans, blowers, pumps, etc., for his design.

We need to estimate what type of concepts an engineer will need and what type of educational tools we must use to teach such concepts in the most educationally efficient way. Among other things, we need to know if we require extensive, in-class analysis in order to teach basic concepts or if we can use new digital tools. A very good and effective approach now with the computers is the usage of simulation for the instruction of engine operations or navigational problems. The student is expected to think and solve problems associated with the ship operation but the problem is visible and realistic. The procedure also offers a student based learning procedure and evaluation.

In my opinion, a student-centered approach is more appropriate, especially for TIL, but an integrated approach with proper checks and balances is also required for professional studies. A recipe for change does not seem to exist, and there may be a number of solutions for a new digital curriculum and the associated environment for the teaching of TIL. In short, we need to answer the following questions:

- How can we respond to the existing value versus preparedness-gap in engineering education?
- How can we effectively use digital (computer-based) general engineering and design tools in education?

We need to bring student-based teaching and modern engineering practice into the classroom and, second, we need to modify engineering education to stress teamwork, design, creativity and synthesis (rather than analysis at this level), possibly leaving analysis to computers. This will require that we bring numerical analysis tools into undergraduate education.

This will not be an easy task and we will need "fluidity" or change. In order to change our educational methods, we must first change our minds. This refers to students' learning, rather than on the role of the student. The main point of discussion for engineering education is, of course, what the engineering curriculum should contain in order to enable students to learn leadership, creative thinking and synthesis.

the fact that change is made by individuals first and then by the institutions and is a highly personal and long experience. This required change of mind may possibly be the most difficult task for educators. We must also decide not to compete with the computer, and we should stop imitating our own old masters, that is, our professors, much as Van Gogh, Gauguin and Matisse stopped painting like their masters. Instead, we should give new digital tools to our students so that they can design the machines they can imagine or dream about. We need to accept the fact that part of the reason for the existence of this gap is that industry is way ahead of universities and colleges in the development and use of computer-aided engineering and design. New engineering tools have not been developed at universities; they are not products of universities; and we really do not know how to use them properly in universities. An additional problem is that even if we have these products, we do not know how to use them effectively for the education of future engineers. In addition, we may not have sufficient space and the necessary infrastructure for teaching a digital curriculum.

All of the above will require that we increase the numerical and digital components of our courses. We recommend integrating computers into our engineering courses and curriculum. In this way the classical, analysis-based component of undergraduate courses could be reduced significantly, and engineering concepts could then be explained through numerical results rather than by extensive analysis.

Computers also offer the opportunity for student-based teaching, thus enhancing teamwork. Engineering case study packages, such as those developed for NSF under the LITEE program, offer the opportunity to introduce students to TIL. I have observed that students do an excellent job of learning when computer-based tools are freely available to them as part of the curriculum.

4. THE CHANGE REPORTED SO FAR

We all observed that most universities are connected to internet in a wired or wireless way. They extended their computer capacities but not necessarily for education and without an integrated approach. In USA National Science Foundation spent substantial amount of money to restructure engineering education. New concepts in teaching were encouraged to increase the quality of engineering education.

[Michael Bernitsas 2002] reported that in the Naval Architecture curriculum at the University of Michigan the following subjects and educational procedures were added to the curriculum.

- The new curriculum (1994) has courses in manufacturing, life cycle cost, industrial design course (second year) before 3rd year core courses.
- Team work, communication skills ethics, environmental awareness, included in (1997-2000)
- Simulation based environments to test virtual prototypes (Computer aided design)

These all seem to be in the direction to close the gap discussed above.

An MIT initiative that could revolutionize learning started in September 2003. The Massachusetts Institute of Technology (MIT), which decided in 2001 to put all of its courses on the Internet, moved its Open Course Ware (OCW) in September 2003. Electronically downloadable books and course ware are now available to all students around the world. This initiative may not reduce the gap but is surely digitizing the undergraduate education and opening new frontiers and opportunities to educators.

[Latorre (1997)] reported the modifications made to the Naval Architecture program at the University of New Orleans. He lists similar short comings and lists modifications made to the curriculum to remove the deficiencies. He also provides a project based future view of the naval architecture program at UNO.

At the University of British Columbia BC Canada (UBCO) a new engineering school started in 2005. With that a completely revised curriculum was designed in

This is a worth studying program as it offers a very creative and a project based environment to the students. Various very effective and valuable course designs are underway. They still remain at individual course or project level and a more comprehensive look at the general engineering undergraduate education as in MECH2 is required and forthcoming. We see rather interesting educational changes and developments in Physics and Medical schools now. [Bronsart R. Clauss G (2006)]reported a very interesting inter university usage of computer aided education in engineering.

5. EXPERIENCE WITH PROJECT BASED LEARNING AT PİRİ REİS UNIVERSITY: FUNDAMENTALS OF ENGINEERING COURSE

This undergraduate course was developed by [Labun (2009)] at UBCO and implemented for the first time in Spring Semester of Academic Year 2010-2011, at Piri Reis Maritime University, Faculty of Engineering. This first-year course aims at introducing students to the engineering profession as well as motivating them for student centered learning.

This course aims to teach the 'metaskills'; the abilities that engineers develop which enable them to analyze situations, design solutions, complete projects, identify professional responsibilities and communicate technical information. These abilities are learnt by doing, so this course emphasizes projects and diverse technical assignments. There is also emphasis on group or team work for project development. The student groups designed, built and competed with their functional designs. The students experienced the benefits and the difficulties of team work and designed, planned, built a working device to perform a well defined task. This is a difficult course to teach but very valuable to students as the skills learned during this course are used in most of the later courses.

This is a four-credit, six-hour per week course and it is implemented for fourteen-weeks with an enrollment of 20- 40 students. Students are required to solve technical problems presented in tutorials, in addition to major projects for competition at the end of the term. Fourteen-week course is structured as follows:

2004. Two of the features for this set of courses are rather unique in engineering education and its application was very successful. During the development of this new engineering program it was agreed upon that all courses and labs would be designed, assuming that the students have a laptop computer. Similar course developments at the mechanical engineering department at UBC resulted with an award winning program called MECH2 for the second year, [Ostafichuk et al (2008)].

The objectives of the curriculum have been developed with input from the faculty, current students and departmental advisory board. Although some content of the course has been successively developed, changed or replaced, the basic structure of the course and the majority of its elements remained the same, up to this day.

Implementation of the course

This six-hour course is implemented as two-hour lecture, two-hour seminar/workshops and two-hour tutorials.

Lectures:

This course is a project based course, so that lecturers use many ways of active-learning in this course. At an appropriate point in the lecture, they ask a topic or questions to the students and request them to write the "minute paper" about this subject. As an example, while discussing heat transfer, design variables and determined variables, one lecturer asked the students to list as many of the principal features of this process, another lecturer asked the students to list some principals of ship resistance in a few minutes while discussing propulsion. Lecturers in general gave a problem to the students individually, and then they asked them to compare their individual answers with the answers of their partners and further synthesize a joint solution to later share with the class. The lecturers formed groups and introduced a topic or a problem for example "safe feeding bottle for a baby", "safety equipments of passenger ships" or " "launching mechanisms of free fall life boat" etc. and then asked for student input, to write down their ideas about the solution, and then to record them on the board. A large number of brainstorming sessions on various subjects were implemented. In addition, the lecturers used case-studies, real-life stories, films, documentary about society, industry, engineers or marine environment. The lecturers gave assignments about these subjects such as essays, calculations etc. and provided feedback.

These activities were deeply correlated with the educational objectives; creativity, teamwork, communication skill and design ability.

Introduction to the course, concepts and metaskills, engineering profession

Design process, brain-storming, intuitional approach

Design and modeling

Multi criteria problems

Creativity

Project timing -project planning, Gantt Chart - PERT Chart, timing in shipyards

Modeling Assumptions,

Team work team development role playing and conflict resolution. Team playing concepts in shipyards,

Modeling usage of tableau solution

Communication, technical communication

Ethics and professional responsabilities, whissle blowers

Worker safety in shipyards

Failure criteria in engineering - Definitions safety factor, failure analysis, control of failure.

Project presentation, evaluation and test

Piri Reis University has a web site PRUONLİNE for communication with students and students could reach all lecture notes, videos, on web page of this course.

Researchers report that, regardless of the subject matter, students working in small groups tend to learn more of what is taught and retain it longer than when the same content is presented in other instructional formats. Students learn best when they are actively involved in the process. Students who work in collaborative

The students in a group perceived that they will "sink or swim" together, that each member was responsible to and dependent on the others, and that one cannot succeed unless all in the group succeeded on their tasks. Students also perceived the group tasks, as integral to the course objectives, and not just busywork. However, this was challenging point of the course, as some students objected as they have never worked in collaborative learning groups, and most of their education had been based on, individual effort and they felt rather uncomfortable in this learning format.

They needed practice and assistance in such skills such as active and tolerant listening, helping one another, giving and receiving constructive criticism, and managing disagreements sometimes sharing of their materials.

Seminars

In this course, industrial and other external actors were involved in, as invited speakers or lecturers or they arranged and hosted company visits for the students. Every week, depending on the subject of the week, a seminar or a workshop was run by an invited speaker. Following this seminar industrial representatives on the same topic gave a seminar to the students about how naval engineers use and apply this subject in their profession, in shipyards or in the marine industry. Sometimes students visited shipyards-company and attended a seminar in the workplace. In this regard the students learned occupational safety and worker's health from an occupational safety specialist in a shipyard.

In a similar seminar the students took some tests on their personalities, creativity forms and had creativity development exercises including 'Writing a short story telling scenario using the given stuff.' 'figuring out extra functions of identified objects', 'finding out functions of an object presented to the class' etc. The students later learned how naval engineers apply creativity from an experienced industrial representative.

The students participated in workshops on communication and presentation techniques. They learned effective communication ways, barriers of communications, how to become a good listener. They formed groups and had the chance to practice during the workshop. An industrial representative gave a seminar on the basics of technical communication in different sections of a shipyard.

Assignments

In general students have 8-10 assignments for this course. Early in the term, lecturers gave relatively easy tasks. As students became more knowledgeable, the difficulty level of the assignments increased. Most of these assignments were done individually and were submitted on internet. They learnt how to write technical reports. Sometimes they were asked to download some freeware programs and use these programs for their assignments as in the development for Gantts charts.

Design Projects

The course is project based and encourages the hands-on approach. The course aims to teach the students the design process, how to set requirements and goals and how to find solutions that meet them.

The design projects were conducted in teams enabling to focus on the development of teamwork and communication skills as well as systems engineering proficiency. Lecturers formed groups of six students at maximum as each member's opportunity to participate might actively, decrease in larger groups,. Sometimes, groups also appear more satisfied with their classes. Thus, team work is promoted and is essential in this course. Lecturers organized informal groups at any time in a class of any size to check on students' understanding of the material, to give students an opportunity to apply what they were learning. They also formed formal learning groups to complete a specific task and to carry out the two assigned term projects. These groups completed their work in a single class session or over several weeks.

lecturer formed the teams considering students' prior achievement levels, levels of preparation, work habits, gender, and students' personality. For some projects, students preferred to form their groups themselves. We observed that in generally self-selected groups worked more efficiently. In tutorials lecturers checked the content of the groups.

In this course, there were at least two design/build type projects. These projects were configured to help the students learn how to design, plan construction and build a device and use most of the meta skills and some of the elementary design skills learned in this course. During these projects, students were directed to experiment basic theorems of science such as Archimedes principle, locating the center of gravity, learning the concepts of buoyancy, displacement, draft changes for different loading conditions and seawater densities in addition to the basic terminology of ships.

Introductory Design: Free fall life boat model design

The purpose of this design project was to improve skills and team experience. Each team was asked to construct a vessel to carry a required cargo (six eggs representing the sailors). The vessels had to float at a specified design draft, float with sufficient stability and move forward away from the free fall point. An electrical circuitry was used to power the indicator light.

Each team built their vessels by using only the limited amount of materials and tools provided. Initially the judges inspected the vessels to verify that they were constructed according to the specifications and to check the accurate placement of the calculated draft marks.

At the end of the projects each team wrote a report and made an oral/visual presentation of their design to an audience comprising the academic staff and the students. Students prepared a design book including the CAD drawings, time charts, design phases and design details. Software outputs for design, CAD, project management and pictures, videos were presented in a CD as a part of the project report.

Students tested their free fall life boat models at sea. The judges measured the distance travelled by the vessel from the free fall point and checked that the indicator light was on. After a few minutes models were removed from the water and were opened to inspect the electronic circuitry and possible damage to the eggs.

Term Projects: Cardboard Boat Design

Each team was asked to build a man-powered cardboard boat to race against time (performance test) consisting of:

- 100 meters dash or a distance between two markers
- A distance marked by two markers on an eight shaped path.

The boat was powered by one person and construction material was cardboard. The teams made the assembly and built the design by using simple hand tools. They were given a budget to learn the basic principles of budgeting.

The students were asked to prepare a design book including CAD drawings, time charts, budgeting, design phases and design details and made the necessary preparations. The written report contained the design steps, conclusions of the brain storming sessions, team organization and project management tools, calculations for buoyancy, structural design, and documentation of the construction phase, results and discussions. Software outputs for design, CAD, project management and pictures videos might be presented in a CD.

Accommodating hands-on approaches from the first year experience made students feel engineering mind and triggered students' motivation. Course evaluation result showed that many students felt what “Engineering” and “Engineering Design” is obtained by hands-on experience.

Assessment and grades

Students were assessed individually as well as in teams in this course. Individual assessment was in the form of written exams, written assignments, project technical reports and drawings. Course had an additional individual, oral presentation and poster presentations. For the projects, all team members got the same grade at first, then individual adjustments were made due to good performance and course attendance. A student's final course grade depended on his/her overall performance. At some universities, for the project based course pass/fail can be used, PRU has five levels of passing grades.

Figure 2 One of the first year projects (free fall life boat project) at Piri Reis University

Feedbacks

Feedback on the course was obtained by interviewing the students. There weren't any written questionnaires or statistical analysis made. Students resisted to the format of this course at first as they were accustomed to a passive listener role. They stated that they were familiar with courses in which lecturer taught the subject directly, so they found the course rather unusual in the beginning. They also stated that they were worried about written examinations due to the structure of the course.

The students said they were impressed with the seminars and benefited a lot from them. They were not used to work as a team, they expressed they had troubles about it. They mentioned in projects some team members did not participate effectively. The students who attended the course previously stated that the writing and oral/visual presentation skills they gained in this course were also very helpful in other courses. They said that they learned brainstorming, process of design and project timing subjects.

Students said they were very enthusiastic about making projects and the course was their favorite in their first years. However, they stated there shouldn't be any written exams as the course is project based.

Visiting lecturers from other universities requested information about implementation of the course. Other academicians from the faculty confirmed that the students are highly interested in the course and motivated about projects possibly too much. They also stated that the students consulted them about technical details of their projects. The course is still developing and we intend to bring a researcher in education to help us in analyzing the impact of the course and the dimensions that need to be added or improved.

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