Preface

These proceedings gather the extended abstracts of talks presented at the Project-Oriented Teaching Conference, organized by the Engineering Faculty of Sami Shamoon College of Engineering, Beer-Sheva Campus. The conference was held on the 31st of May 2018. The main target of the conference was to share the experience gained during the process of teaching various courses in different departments using the PO method. Furthermore, the conference provided the opportunity to discuss the ways of enhancing the implementation of the PO method. We thank all the authors who submitted short papers included in these proceedings and all the participants of the conference, who contributed to making it a significant and enjoyable event.

Program Committee

Prof. Levitsky S. (Chair)
Dr. Danoch A.
Dr. Baimel D.
Dr. Fisher E.
Mr. Michaelan R.

Organizing Committee

Ms. Gersh T.
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Editors: Levitsky S., Baimel D., Michaelan R.
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Conference Program

08:30-09:00  Reception

09:00 -09:15  Opening

Prof. Jehuda Haddad, President of SCE  
Prof. Semyon Levitsky, Dean of the Engineering Faculty, Beer-Sheva Campus

Session I  Prof. Semyon Levitsky (Chair)

09:15-09:40 Dr. Amnon Glassner, Kaye Academic College of Education  
"Project-Based Learning in Higher Education: Cognitive, Social and Emotional Aspects"

09:40-10:00 Dr. Dagan Bakun-Mazor, Civil Engineering, SCE  
"The Experience of Teaching a Seismic Hazards Course for Civil Engineering Students Using the Project-Oriented Method"

10:00-10:20 Dr. Oshrat Ontman, Chemical Engineering, SCE  
"Project-Oriented Teaching Approach in Chemical Engineering Education"

10:20-10:40 Dr. Dmitry Baimel, Electrical and Electronics Engineering, SCE  
"Implementation of Project-Oriented Teaching in a "Smart Grid" Course"

10:40-11:00 Dr. Zak N. Turbovich, Mechanical Engineering, SCE  
"Implementation of the Project-Oriented Method in an Introductory Engineering Design Course"

11:00-11:20 Coffee Break

Session II Dr. Avshalom Danoch (Chair)

11:20-11:40 Mr. Idan Horesh, Israel Aerospace Industries  
"Advantages of the Project-Oriented Teaching Method for Graduates in Mechanical Engineering"

11:40-12:00 Dr. Dmitri Alberg, Industrial Engineering and Management, SCE  
"Business Intelligence Project-Oriented Course: A Breast Cancer Research Case"

12:00-12:20 Dr. Galina Reshes, Physics Unit, SCE  
"Physics Laboratory Teaching in a Project-Oriented Environment"

12:20-12:40 Mr. Dan Almog, Software Engineering, SCE  
"Project-Oriented Learning within an Agile Atmosphere: Emergence of a Pedagogical Development in Software Engineering"

12:40-13:30 Panel Discussions and Closing Remarks, Chairs: Dr. Dmitry Baimel, Dr. Etan Fisher

13:30-14:00 Lunch
Greetings from the President of Shamoon College of Engineering

The project-oriented method is based on learning through action in a variety of courses while studying for a degree. When using this method, students work in groups and try to solve "real world" engineering problems with close academic and practical guidance adapted to the changing reality.

We at SCE have been implementing the project-oriented learning method already for several years, preparing the students for labour markets and the changes taking place in them, while coordinating between the curricula and the technological reality and improving the students' adaptability to the swift changes that are taking place in the world. Providing the students with learning skills as well as cooperating with the industry help the students practice flexible thinking which adapts itself to the conditions and data in the field. SCE graduates arrive at a workplace with practical advantages and with much more suitability for the job because they have experienced real situations a great number of times throughout their academic studies.

The project-oriented learning method requires a great deal of efforts and resources, not just from the students, but also from the institution, which is required to provide teaching in small groups with individual instruction, cooperate with the industry, etc.

The PO Conference presents us with theories and methodologies we should get to know and learn, and thus acquire additional tools for deepening and expanding our knowledge of how to integrate the PO method into our curriculum.

Prof. Jehuda Hadad
Greetings from the Engineering Faculty Dean

During the conference, which is a landmark in the development of the project-oriented learning method in Israeli academia, faculty members from different departments of our college will deliver their lectures, alongside the lecturers of academia and industry guests. Starting already at the 2018-2019 school year, the college will significantly increase the number of courses taught via the PO model, to the extent of about 60 PO courses a year, beginning with the first year of studies.

One of the considerations behind the process is that in order to achieve professional success after graduation, it is no longer enough to have obtained high grades in all the courses taken. One could say that this is a necessary condition, but what makes it also sufficient is having creativity and the ability to cooperate and work effectively in a team, as well as to think "outside the box."

The college has long been advocating these principles. We believe that one of the main tools of implementing them is increasing the number of PO courses and broadly implementing the learning through action which they are based on. The unique curriculum developed in the college combines academic education with research and industrial experience, self-study and teamwork, which is a common practice in various high-tech and engineering industries. We believe that it will help students gain professional experience already during their studies and contribute to their future success. We are happy to observe that the project-oriented work perception is highly acknowledged and appreciated by the industry.

Prof. Semyon Levitsky
Project-Based Learning in Higher Education: Cognitive, Social and Emotional Aspects

A. Glassner

Kaye Academic College of Education, Beer-Sheva, Israel, amnonglassner55@gmail.com

Abstract – The paper describes the Project-Based Learning (PBL) approach and methodology. The strengths and the opportunities of PBL are discussed with emphasis on emotional, social and cognitive aspects. Furthermore, an example of PO project is presented. The conclusions are derived at the end of the paper.

Keywords – PBL, SDT, Emotional, social and cognitive aspects.

I. INTRODUCTION

Project-Based Learning is a teaching/learning approach which based on progressive pedagogical ideas such as learning from experience, learning by doing and learning authentic contents (i.e. issues, needs, questions, problems), which are relevant to the students' daily life or to their communities or environmental needs [1-3]. In PBL, the learning process is based on conducting a project. Students need to learn contents and develop skills to initiate and manage a project. Students prepare themselves for real-world challenges by learning how to cope with complex problems, issues, needs, or questions by means of projects execution. Planning and implementation of projects like opening businesses, organizing campaigns, creating video clips, designing and building different kinds of models, algorithms or structures motivate students to learn the relevant contents and to develop the required skills.

The role of the teacher/lecturer in PBL is to set a challenge for learning and then to mediate students' self-learning process as individuals or in groups by facilitating dialogues of thinking and reflection. The lecturers may also invite the students to identify and choose challenges and projects [2]. Nevertheless, the lecturer should draw some guidelines for the learning process, such as guidelines for the qualities of the product and the way of its evaluation.

The Patton teacher’ guide [4] describes two main principles for good PBL. The first one emphasizes the importance of exhibition since students know they will need to ‘stand by’ their project, taking responsibility and obligation for the qualities of their products. The second principle emphasizes the need for multiple drafts before presenting the final products of the project. This is how students can achieve high-level products. Multiple drafts help to assess the student’s final product and the process development.

II. STRENGTHS AND OPPORTUNITIES OF PBL

The strengths and the opportunities of PBL that influence the quality of the learning processes, products and constructed knowledge can be divided into three aspects: the emotional, the social and the cognitive.

A. The emotional aspect

By planning and managing projects and producing high-level products, students get a great opportunity to strengthen their basic emotional needs for self-efficacy, self-autonomy, relatedness and connections with other people, communities and environments [5]. People need to feel self-efficacy (i.e. to feel worthy as a person with talents and abilities). They need to feel autonomy (i.e. to feel they can control and direct themselves to design and achieve their goals and dreams). In this context, they also need to feel free to choose their own goals. When someone has a chance to choose, it is legitimate to demand from him to be responsible for his choices. In addition, people need to feel relatedness and connections to others (i.e., to feel worthwhile and belong to their family, groups, communities and environments).

PBL invites students to plan, produce and present the projects by themselves. Such
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autonomy can increase the probability to experience self-efficacy and self-autonomy feelings during and after learning, especially when the students succeed in coping with challenges and difficulties. Producing projects to advance communities or environmental issues, needs and problems enable the students to foster their feelings of relatedness and connections to those communities and/or environments. When each of the students has the opportunity to demonstrate his or her unique talents to advance the project, they may reinforce their feelings of self-efficacy and self-esteem. These two last cases are also connected to social aspect.

B. The social aspect
Working with others in teams demands and develops social skills like communication and argumentation. Students should listen to their mates’ ideas in order to expand and deepen their own. They need to share their own ideas, to argue and convince others, to think together in a collaborative way to reach conclusions and make decisions, and to contribute to their team by performing the part work assigned to them cooperatively. PBL encourages teamwork and enables the students to develop those skills.

B. The cognitive aspect
PBL invites the students to raise ideas about how to initiate, plan, produce, manage and present a project. Such process enables the students to develop their creative and critical thinking dispositions and skills. They need to create alternative solutions and processes using creative thinking, and to choose the best one using argumentation and critical thinking. They also have to develop their abilities to think and learn by themselves (i.e. to learn how to learn) which includes identifying relevant and reliable sources of information, processing information to advance relevant well implemented ideas, representation and manifestation of the constructed knowledge.

III. EXAMPLE OF PROJECT

A group of students studied the need of stuff in hospital for mentally-ill youth to protect their patients from committing suicide in the hospital’s bathroom. On one hand, the stuff should protect the youth privacy, and on the other hand, they should keep an eye on them and protect their life. The students built a special sensors’ detector (infrared) that follows the youth movement in the bathroom without exposing their body parts. The sensors’ detector warns the stuff in case of suspicious absence of movement.

Such kind of authentic challenge has a great potential to increase the inner motivation of the students to learn the problem and to develop an implemented solution. Such process and product may satisfy the students' need for self-efficacy, self-autonomy, as well as connect their team members to the youth and the staff in the hospital. It develops their social and cognitive abilities and skills.

REFERENCES
The Experience of Teaching a Seismic Hazards Course for Civil Engineering Students Using the Project-Oriented Method

D. Bakun-Mazor

SCE, Department of Civil Engineering, Beer-Sheva, Israel, daganba@sce.ac.il

Abstract – This paper describes the experience of teaching the course "Introduction to Earthquakes" in the Department of Civil Engineering of Shamoon College of Engineering (SCE), using the problem-based learning method, within the framework of Project-Oriented (PO) environment. The aim of this course is to expose students to the basic concepts of earthquake seismology and to introduce the computational tools used for engineering characterization of ground motion and seismic hazards. The students in the course had to independently study subjects they had chosen from the syllabus subject list and design models that would illustrate these topics. The motivation was to present the models at an exhibition that would be open to the public at the end of the semester, and a competition was announced, at the end of which three of the best models would be showcased at the educational exhibitions of the "Carasso Park of Science" in Beer-Sheva. The criteria for rating the models were: visibility, creativity, clarity, and the level of students’ knowledge. It was evident that the students put a vast amount of effort to achieve optimal visibility and creativity. Nevertheless, the knowledge level in certain cases was not high enough, and it was not always clear what point the students tried to illustrate. The main lesson derived from experimenting with the PO learning method was that students should be guided to use high-quality scientific literature sources and not to rely on an independent internet search only.

Keywords – Problem-based learning, Earthquake, Seismic hazards.

I. INTRODUCTION

Civil Engineering students at Sami Shamoon College of Engineering (SCE) are offered a course titled “Introduction to Earthquakes”. The course, which is a part of the Bachelor of Science syllabus for the third year of study, is designed to endow the students with knowledge about earthquakes and seismic hazards. The course objective is to expose the students to basic concepts of earthquake seismology and to acquaint them with the computational tools used for engineering characterization of ground motion [1-4]. Additionally, the students learn about the earthquake-related phenomena, such as liquefaction [5, 6], slope stability problems [4], and tsunami [2, 5], and receive basic tools to calculate mechanical problems associated with these phenomena.

In the spring semester of 2015, as a pilot project, the course was taught using the problem-based learning method. The students had to independently study subjects they had chosen from the syllabus subject list and to design models that illustrate these topics. The motivation was to present the models at an exhibition that would be open to public at the end of the semester.

II. PO IMPLEMENTATION

The course commenced with a frontal lecture that provided a general overview of earthquakes and their engineering consequences. The objectives of the course were defined and the stages of self-study over the course of the semester were outlined. The project stages included a meeting with the instructor who provided the students with guidelines for writing the preliminary report and citing relevant literature sources. A month later, the students submitted the preliminary report, where they described the theoretical background of the subject they had studied, the purpose they would like to achieve when presenting the subject to public and the work plan for achieving it. The reports were examined and returned to the students in order to better prepare them for the task. To motivate the students, a competition was announced, at the last stage of which three of the best models would be showcased at the
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The experience of teaching seismic hazards course for civil engineering students using a project-oriented environment.

The Project-Oriented Teaching Conference SCE, Beer-Sheva Campus, May 31, 2018

educational exhibitions of the "Carasso Park of Science" in Beer Sheva. The members of the referee panel who evaluated the models, included experts in the field of earthquakes as well as Carasso Park representatives. The criteria for rating the models were visibility, creativity, clarity, and the level of knowledge exhibited by the students.

III. EXAMPLES OF MODELS AT THE EXHIBITION

The exhibition was scheduled for the final week of the semester. The exhibition was held in a public area in order to increase the exposure of the models and thereby increase the motivation and commitment of the students. The examples of selected models are shown in Figs. 1-4.

Fig. 1. The model shows the tectonic plates boundaries and the seismic active areas in northern Israel.

Fig. 2. Models show the concepts of seismic wave propagation (left), and the concepts of real-time tsunami early warning system (right).

Fig. 3. The model shows the components of the modern seismometer (left) and the principles of the ancient Chinese seismograph (right).
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Fig. 4. Models show the principles of a system for earthquake early warning alert in Israel (left) and one-story building on a man-made shaking table (right)

III. CONCLUSIONS

It was evident that the students put a considerable effort in order to achieve optimal visibility and creativity; all of the models looked inviting and were well-marketed. Nevertheless, the referees concluded that the knowledge level in certain cases was not satisfactory and it was not always clear what point the students tried to illustrate. The main lesson derived from experimenting with this learning method was that students should be guided to use high-quality scientific literature sources and not to rely on an independent internet search only.

REFERENCES

Abstract – This paper deals with the experience of the chemical engineering staff of SCE in using PO approach as an applied teaching technique. The PO courses usually include the design of a particular product or the process of real-world problems, either by teams or by individual students. Some courses include both a team component and an individual component in order to allow students to experience the benefits and challenges that are associated with both approaches. We have particularly focused on the experience of teaching of the course “Advance Reactors and Scale-up”, which is an elective course taught in the second semester of the fourth year. The course deals with three-phase catalytic reactors operation and applications. It focuses on self-studying and writing a project in a group. At the beginning of the course, each group has to study various topics, including heterogeneous catalysis and advanced reactors. Then, these topics are implemented in a project that deals with the assessment of three-phase reactor in a certain catalytic reaction and scale-up. The project includes literature survey on various reactors for a selected reaction, selection of one of the processes based on operation aspects, and the detailed description of the selected reactor accompanied with mass and heat balances, as well as scale-up. The students receive guidance and have several meetings with the professor during the semester where they have to show their progress.

Keywords - Chemical engineering, Project-oriented, Skills.

I. INTRODUCTION

Chemical engineering is a discipline involving different areas of technology, which are part of industrial scale processes, including chemistry, biotechnology, food, agriculture, etc. In broad terms, chemical engineers conceive and design processes to produce numerous materials, which are necessary for working in various industries from laboratory experimentation to technology implementation in full-scale production. They are also in charge of developing and controlling methods for cleaner production. Therefore, the chemical engineers should be equipped with multidisciplinary skills, which will provide them with the ability to analyze, design, operate processes, and deal with the chemical and biological nature of materials, from molecular to macroscopic length scales. These unique skills are essential, and are being embedded through four-year studies (eight semesters) in the program of the Department of Chemical Engineering (SCE). The program provides our students with a challenging, broad, and flexible education, which will help them to become highly qualified and expert chemical engineers able to meet the challenges of tomorrow and successfully carry out their work in an increasingly competitive global environment. The study program of the Department of Chemical Engineering consists of two specialization tracks: industrial processes and biotechnology. In addition, the study program consists, roughly speaking, of two parts: the first two years focus on core scientific and technological courses, while the last two years are focused on their integration in the chemical engineering discipline and in more state-of-the-art knowledge and tools of the field. In the last two years of the study program, the students received a significant level of exposure to the chemical and biotechnological industries in the courses, in massive laboratory experiments during the final project, and through tours of industrial facilities and meetings with experts from the industry.

The predominant model of engineering education “chalk and talk”, in which single-disciplinary, frontal lecturing in large classes is the dominant teaching technique, particularly
in the early years of study. However, in the last decade the PO approach has increasingly been tested and adopted among many education institutions worldwide [1].

II. PO IMPLEMENTATION

The Department of Chemical Engineering of SCE has been using the PO approach for the last four years. Nowadays, nine courses are studied with the aid of the PO approach, including the "Bioreactors Design and Scale-up", "Separation Processes", "Advance in Chemical Engineering 3", "Topics in Green Engineering", "Advance Reactors and Scale-up", "Information Retrieval", "Microbiology in the Chemical Industry" and "Separation and Recovery Processes in Biotechnology" courses. In addition, laboratories courses are a large part of the PO study program. These laboratory courses are self-studied and require teaching skills in groups.

The PO courses studies usually include the design of a particular product or the process of real-world problems, either by teams or by individual students. Some courses include both a team component and an individual component in order to allow students to experience the benefits and challenges of both approaches. In some cases, the courses also include lectures that accompany the product or process design. Subjects that are covered in lectures correspond to the current issues and concerns in the students' design projects.

The course requirements can be divided into few stages. The first stage is to define the project, which includes preparing a literature survey relevant to the project and writing a preliminary proposal for designing a product or a process. In the second stage, the preliminary proposal needs to be approved by the supervisor. In parallel to the approval stage and thereafter, students are guided by the lecturer during several meetings, where they have to show their progress and their submission exercises. During these meetings, the lecturer can evaluate the students' progress, and advise them how they should proceed by defining stages toward accomplishing the final project goal. At the end, the students need to write a final report and/or present their project in front of the class and the supervisor. All the project planning and analysis are written based on earlier education that was implemented in traditional frontal education approach.

III. EXAMPLES OF PROJECTS

The nature of the project depends on the course and the stage at which the course is studied. The typical PO course is “Advance Reactors and Scale-up”, which is an elective course that is taught in the second semester of the fourth year. The course deals with three-phase catalytic reactors operation and applications. It focuses on self-studying and writing a project in a group.

At the beginning of the course, each group has to self-study various topics, such as heterogeneous catalysis and advanced reactors. Afterwards, students have to submit corresponding exercises that are given by the lecturer. Then, these topics are implemented in a final project that deals with the design and scale-up of three-phase reactor for a certain catalytic reaction. At the beginning of the project, each group is assigned with a certain chemical reaction. The project starts with a literature survey on the selected reaction and various reactors for this reaction, followed by submission of a project proposal.

The proposal includes background about the chosen reaction or process that consists of a short explanation, importance, uses, working conditions, possible catalysts (at least two different catalysts), as well as relevant chemical, kinetic and thermodynamic data. The proposal also includes two different possible reactors that can be used for this reaction and a short explanation about the types of the reactors including their advantages and disadvantages.
Additionally, a photocopy of at least five different relevant articles must be attached. The proposal is submitted to the lecturer, who should authorize the proposal and give remarks.

The second stage of the project deals with selection of one of the reactors based on operation aspects, performances, price, environmental aspects, etc. At this stage, the group is obliged to meet the lecturer and answer different questions while defending their selection. The final stage of the course includes the submission of a project and present the project in front of the class. The final project should include: (1) Background - a literature survey on the chosen reaction and reactors; (2) The chosen system - explanations about the principles that were used to choose the final system (reactor, catalysts and conditions); (3) Detailed mass and heat balances for the chosen system; (4) Scale-up of the chosen system.

Since the first year program contains more basic scientific courses then the other years, most of the PO courses are studied in the third and the fourth years. However, we are trying to embed the PO approach also in the first years of studies by giving tasks for self- studying of various topics before exams in both frontal and laboratory courses. In addition, the "Information Retrieval" course, which is a basic mandatory course given in the second semester, also adopted the PO approach. In this course, for the first time, the students are exposed to one of the challenges of the engineer's work, which is to present their results through a scientific report and a presentation. The work is done by a team and is carried out in a number of steps. In each step, the students study some principles in writing and need to present their scientific results at the end of the course. At the end of each step, the team meets with the lecturer for examination of its work and for learning additional contents. At the end of the course, the students have to write a scientific report. In order to write it, the students have to find a relevant article, information and data from the literature. At the end of the course, they have to present their results in front of an audience.

The challenges of the course constitute the main difficulty the students face, i.e., in a hectic semester and during the first year of their degree, the students have to manage their time schedule and submit their assignments on time. As part of the course, the students need to work in teams, listen to various opinions and write an advanced scientific report, according to a new scientific approach. They are also having difficulties in presenting their work by an obligatory oral presentation in front of the class. The main difficulty of the lecturer is to deal with students' training in order to develop their skills and adjust them to incorporate life-long learning abilities. It is common in the industry to present the work in the form of a scientific report and an oral presentation. Therefore, the aforementioned challenges prepare the students for the following years in the academia and the industry.

IV. CONCLUSIONS

We believe that the PO approach gives students an opportunity to work together on real engineering problems, and "puts theory into practice". The approach motivates them and encourages their initiative and independent thinking. Indeed, it is reported that with its hands-on experience, real-world problems and group work it is seen as providing these wider transferable skills [2]. This approach also gives the students a taste of future, work through immersion in an actual professional context [3-4], and enhances their skills and employability. Furthermore, the PO courses approach combines between different chemical engineering skills and includes library research, written and oral communication, and submission of a project. It also trains the students to collaborate and work in groups and to plan their schedules in accordance with the allotted time, which is of utmost importance for their future professional career.
O. Levy-Ontman, A. Burg, Y. Shotland, D. Tavor, A. Wolfson “Project-Oriented Teaching Approach in Chemical Engineering Education

REFERENCES

Implementation of Project-Oriented Teaching in a "Smart Grid" Course

D. Baimel

SCE, Department of Electrical Engineering, Beer-Sheva, Israel, dmitrba@sce.ac.il

Abstract – The presented paper describes the implementation of the project-oriented approach in a "Smart Grid" course. The application of the PO method is described in detail, including the course purposes and requirements, the schedule of the meetings between the lecturer and the students and the grading policy. Furthermore, an example of a micro-grid project is presented and explained. The conclusions are presented in the last section of the paper.

Keywords – Project-oriented, Smart grid.

I. INTRODUCTION

The main objectives of the PO "Smart Grid" course are to give the students tools for independent thinking and independent working, team work, as well as conducting research in the field of smart grid. The smart grid is the electrical grid of the future and it includes a variety of sub-fields such as power systems, smart generation plants, smart distribution, communications, cyber security of the grid, machine learning, electrical vehicles and algorithms [1-4]. This course includes the most recent developments in all mentioned fields and exposes students to the newest technology that is being developed. Students can choose a project in one of the mentioned fields according to their preference. This course has been taught using the PO approach for the last four years.

II. PO IMPLEMENTATION

In the "Smart Grid" course, the students are divided into groups of 2 or 3 student per group. The lecturer proposes a variety of projects to the groups. Some projects are to design and simulate already existing systems, whereas others are research projects. Moreover, the students are encouraged to propose their own topic for the project. The topic will be accepted if it is suitable for the required level and meets the requirements of the course syllabus.

Each group must hold a meeting with the lecturer at least once a week, during the semester. The participation in the meetings is obligatory for each student. Furthermore, the lecturer encourages the groups to meet him more often during the week in order to enhance their progress in the project. During these meetings, the lecturer gives assignments for the next meeting and checks how they performed assignments from the previous one. The lecturer also asks students questions in order to assess the level of their knowledge and their progress. The lecturer plans the assignments in such a way that by the end of the semester, each group will finish the project. The well-defined meetings schedule is very important for the students' success because it helps improve their discipline and make them aware of the necessity to be prepared for the next meeting.

At the end of the semester, the groups have to submit to the lecturer their project report. The report is built in the same format as academic manuscript. It includes an introduction, state of the art, simulation results, experimental results and a conclusion. The report length is about 20 pages. The report constitutes 50% of the final grade and this grade is equal for all the members of a group.

After the submission of the report, each group has an oral exam with the lecturer which is 50% of the final course grade. During this exam, the lecturer asks questions about their project or topics related to the project. Each student is asked different questions and gets different exam
grade according to his/her level of knowledge. The purpose of this exam is to understand who was more engaged in the project and has reached a higher level of knowledge.

III. EXAMPLE OF PROJECT

There are a lot of possible projects in the field of smart grid. The most common that were implemented in the frame of this course are design and simulation of micro-grid, design and simulation of electrical vehicle, development of pricing definition algorithms, development of energy sharing and load prediction algorithms, development of cyber security algorithms, design and simulation of Phasor Measurement Units (PMU), integration between micro-grid and main grid and more.

In this section, an example of the design and simulation of a micro-grid PO project is presented. A scheme of a standard micro-grid is shown in Fig. 1. It consists of several main components - solar power source, wind turbine power source, energy storage systems. The micro-grid has AC and DC buses that feed AC and DC loads. In order to connect DC and AC buses, the inverter is used. In order to match the DC voltage at the output of the solar system, the DC-DC converter is used.

The project preparation is divided into several stages. During the first stage, the students have to understand in depth the working principle and theory of each component that was mentioned above. During this stage, students have a great number of theoretical questions due to the variety of components and their complexity. The second stage is the design and simulation of each component in Matlab. Students perform several simulated experiments with each component in order to better understand its working principle. In the example that is shown in Fig. 2, students connect a wind turbine to different loads and change the wind speed during the simulation. By performing this experiment, they can analyze the transient behavior of the wind turbine. The problems that students usually encounter at this stage are the design of Simulink blocks and their interconnection. The third stage is the integration of all the components together and the simulation of the whole system. The main problem at this stage is incorrect definition of the components’ parameters that influences the integration process and causes errors.

During these three stages, the students learn a vast amount of new theoretical material, significantly improve their skills in Matlab and learn to analyze complex power systems that have several large components.
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The first challenge for the lecturer in this project is to make sure that theoretical knowledge obtained by the students is deep enough and meets the course requirements. The second challenge is high-level training of students in Matlab. The third challenge is to provide the students with the skills necessary for research analysis.

Fig. 2. The wind turbine connected to the grid

IV. CONCLUSIONS

Based on the experience of the PO courses, the most important thing for the students’ success is to reach a high level of discipline. The main tools for the creation of rigid discipline are obligatory weekly meetings and well-defined assignments for each group. A complex project should be divided into many accurately defined small tasks that are easier to perform.

The main challenge for the lecturer is to help the students perform these tasks in a defined time schedule. An additional challenge is to motivate the students by providing them with interesting projects that will stimulate them. Moreover, the lecturer must teach the students to work as a team, to think independently and to analyze project results.

REFERENCES

Implementation of the Project-Oriented Method in an Introductory Engineering Design Course

Z. N. Turbovich

SCE, Department of Mechanical Engineering, Beer-Sheva, Israel, zuktu@sce.ac.il

Abstract – The paper describes how the Project-Oriented (PO) method is implemented in the "Introduction to Engineering Design 1" and "Introduction to Engineering Design 2" courses, which are the 1st and 2nd PO courses that second year students from the Machine & Product Design program at the Department of Mechanical Engineering are learning. The paper also refers to the international MECHATON - a PO workshop related to the above-mentioned courses.

Keywords – Project-oriented, Knowledge-implementation, MECHATON.

I. INTRODUCTION

In the Department of Mechanical Engineering (ME) at the Shamoon College of Engineering (SCE), starting from the 2nd year of studies until completion of the degree, students must choose a program in which they will be specialized in a specific field, in addition to the general ME field. The optional programs are: Energy Systems, Mechatronics, and Machine & Product Design (M&PD). This paper deals with "Introduction to Engineering Design 1" and "Introduction to Engineering Design 2" courses, which are the first and second Project-Oriented (PO) design courses that students from M&PD Program take during their 2nd academic year.

The design of the program's curriculum is similar to that used in other academic institutions teaching ME. During the first year, students are initially required to establish scientific theoretical basis by taking math, physics, and chemistry courses, along with other additional courses, few of which relate specifically to ME, e.g. "Engineering Graphics" (first semester), "Computer Graphics, and Statics" (second semester). In general, the curriculum committee of the department (lead by the Head of the Department, Dr. Gedalya Mazor) sees the implementation of theoretical knowledge acquired prior to the course as the most important benefit of PO courses. The committee strongly believes that the implementation of theoretical knowledge through doing real projects provides the students with a much deeper understanding of the topics that have been taught. Additionally, the implementation provides a wider perspective of the topics. As a result, the quality of students as mechanical engineers in the future will be improved and this will help them in looking for a job as a practical mechanical engineer, or to continuing to postgraduate studies.

Therefore, in this context, the Curriculum Committee of the M&PD program (lead by the Head of the Program, Prof. Iko Avital) have proved the general strategy for the above mentioned courses. The general strategy, as described in Fig. 1, takes into consideration the perspective of the Curriculum Committee, and adds values that important to students at the M&PD program. In addition, close to the end of the academic year, the department organizes a cluster of unique events appointed for 2nd, 3rd, and 4th year students.

The event for the students who are completing their 2nd year is called ‘MECHATON’ (Mechanical Hackathon), and it is considered as an inseparable part of the mentioned PO courses (also noted in the syllabus of these courses). The ‘MECHATON’ is a short-time international multidisciplinary workshop in creativity and design that lasts four days. The participants of the workshop are the students from different disciplines from a variety of institutes, professors from foreign institutes, and industrialists that challenge the students with real design and engineering problems. The purpose of the ‘MECHATON’ is to practice
knowledge that was taught in the mentioned PO courses, and to absorb the values that were determined in the general strategy, with a greater impact.

II. PO IMPLEMENTATION

This section refers to each course separately, but it should be comprehended as a one whole unit. The first PO course, "Introduction to Engineering Design 1", is actually the first PO course that needs to be taken by 2nd year students from the M&PD program. The structure of the course was formed according to the values noted in the general strategy and the actual content with relation to the determined values presented in Table I.

Since the students come from different background, and their experience in design is naturally not equal (the vast majority have no experience at all), the aim of the course was to create a common language. Prior to designing an actual product, this course focuses on teaching fundamental concepts in engineering and industrial design, by analyzing a readymade product. The students, who were divided into work groups of two get products, e.g. citrus juicers, articulated clamps, vise-grips, etc., which the department buys for this course, and do
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comprehensive analysis according to the factors listed in the course guide booklet. The general structure of the course was formed according to the values noted in the general strategy.

### TABLE I
**IMPLEMENTATION OF THE VALUES OF THE GENERAL STRATEGY IN THE 1ST COURSE**

<table>
<thead>
<tr>
<th><strong>The Value</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Implementation of theoretical knowledge</strong></td>
<td>- Engineering Graphics&lt;br&gt;- Computer Graphics&lt;br&gt;- Statics</td>
</tr>
<tr>
<td><strong>Self-learning</strong></td>
<td>- User Requirements Specifications (URS) document&lt;br&gt;- Market review and classification of the product&lt;br&gt;- Analysis of technological design considerations</td>
</tr>
<tr>
<td><strong>Utilitarian research</strong></td>
<td>- Practical reverse-engineering limited research</td>
</tr>
<tr>
<td><strong>Teamwork</strong></td>
<td>- Working groups in pairs, each group is guided by a mechanical engineer and a product designer</td>
</tr>
<tr>
<td><strong>Advance non-academic knowledge</strong></td>
<td>- Advance part modeling techniques (SolidWorks)&lt;br&gt;- Introduction to GD&amp;T&lt;br&gt;- Technical presentation</td>
</tr>
<tr>
<td><strong>Collaboration with industry</strong></td>
<td>- No collaboration with industry is done in this course</td>
</tr>
<tr>
<td><strong>Gaining experience in practical tools</strong></td>
<td>- Reverse computer modeling&lt;br&gt;- Technical drawings&lt;br&gt;- Technical writing&lt;br&gt;- Measurement techniques</td>
</tr>
<tr>
<td><strong>Solving open problems</strong></td>
<td>- Suggestions for improvements in the analyzed product</td>
</tr>
</tbody>
</table>

At the end of the course, each group submits a comprehensive "Reverse Engineering" report (this is the main project). Preparation of this report is a process that every mechanical engineer must be skilled in preparing. The report presents the product graphically and specifies all the conclusions drawn from the analysis that were performed during the course.

The final grade is comprised of numerous factors: 30% - quizzes and participation (10% GD&T quiz, 10% initial market review presentation, 10% participation); 70% - final exam (45% for the "Reverse Engineering" report and 25% for the final presentation).

Evaluation criteria are published to the students in the course's booklet guide with the help of which they understand from the start how they will be assessed.

After examining a readymade design and experiencing a "Reverse Engineering" process, the students start their first actual design course, "Introduction to Engineering Design 2". As in the first course, the structure was formed according to the values noted in the general strategy and the actual content with relation to the determined values presented in Table II.

This course is carried out in collaboration with "Carasso Science Park", Beer-Sheva, and the students are required to design and produce an educational wooden toy intended for teaching scientific or mechanical principles to children aged 6-12 (the project). The design process is being done by professional product/machine design methodologies, e.g., Pahl & Beitz and DVI2111 [1].

At the beginning of the course, the students visit "Carasso Science Park" and meet the staff, who delivers them the requirements and the perspective of the client. At the end of the course,
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the students are requested to produce a working prototype of the toy, prepare a report of the documents and explain the design process. The students also prepare a short technical presentation. The presentations are held at the park in the presence of the park representatives, and right after that the students place the toys in the park's area and kids will play and experience the toys. This long-lasting collaboration provides the students with genuine feedback from their clients (the park and the kids), something which is rare in academic courses. Most of the students show high motivation during the course and many toys remain in the park to be used in training.

**TABLE II**

**IMPLEMENTATION OF THE VALUES OF THE GENERAL STRATEGY IN THE 2\textsuperscript{nd} COURSE**

<table>
<thead>
<tr>
<th>The Value</th>
<th>Description</th>
</tr>
</thead>
</table>
| Implementation of theoretical knowledge | - Engineering Graphics  
- Computer Graphics  
- Statics                  |
| Self-learning                     | - User Requirements Specifications (URS) document  
- Market review and classification of the product  
- Analysis of technological design considerations |
| Utilitarian research              | - User Requirements Specifications (URS) document  
- Market review                    |
| Teamwork                          | - Working groups in pairs, each group is guided by a mechanical engineer and a product designer |
| Advance non-academic knowledge    | - Professional product / machine design methodologies                         |
| Collaboration with industry       | - Collaboration with "Carasso Science Park"                                    |
| Gaining experience in practical tools | - Modeling  
- Technical drawings  
- Technical writing |
| Solving open problems             | - The main project                                                            |

The final grade is comprised of numerous factors: 10\% - participation and involvement; 10\% - toy made of cardboard (brief project at the beginning of the semester); 80\% - the project (50\% - the actual toy quality, 30\% - the final report).

Evaluation criteria are published to the students in the course's booklet guide with the help of which they understand from the start how they will be assessed.

III. EXAMPLE OF PROJECT

One of the toys that were designed and produced for "Carasso Science Park" is presented in Fig. 2. The toy, 'Moonlift', which was designed and produced by Yuval Rothenberg and Yaron Agay, 2\textsuperscript{nd} year students, was designed to demonstrate Bernoulli's principle (the lift force). The kid is supposed to rotate the operating handle (colored in green) with a view to produce sufficient airflow through manual operation of an air-pump. The goal of the operation is to lift a plastic ball as higher as possible. This project, which is similar to other design projects, faces many issues that need to be solved during the design and manufacturing processes. The main difficulty of this project was to properly design the airflow's generator mechanism so that it would produce enough rounds per minute and constant airflow. An example of Free-Body
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diagram of the mentioned mechanism, which is one stage in the theoretical process, is presented in Fig. 3.

Fig 2. "Moonlift" – design by Yuval Rothenberg and Yaron Agay

Fig 3. Free-Body diagram for a part of the toy

III. HACKATHON TRAINING

At the end of every academic year the department organizes an international MECHATON for 2nd year students from M&PD program, with participation of students from abroad (usually studying industrial design, but not only), guided by the faculty of the department together with professors from other institutes from abroad, and with participation of international companies (Soda-Stream, Netafim, Polygon-Tamarisk, etc.). At the end of the above-mentioned brief workshop, the students present their results (see Fig. 4 and 5), and an international jury panel ranks the outcomes. Cash rewards are given to the first, second and third place winners (sponsored directly by the SCE president, Prof. Yehuda Haddad), a factor that increases the participants’ motivation.

Basically, this MECHATON is a brief rehearsal of the mentioned courses, with greater impact (because of the platform). Most of the students describe the MECHATON as unforgettable event, and all the parties consider it as a successful event that contributes to all of them.

Fig. 4. A device that locate and extract pins from an injection mold

Fig. 5. A solution to prevent the fall of a gasket from the gaseous mechanism when transporting
IV. CONCLUSIONS

Many graduated students point to the PO courses as the key factor that provided them with a better understanding of the design process and what is required from them as mechanical engineers. Since doing a project is magnetizing, student reported that they dedicate many hours to doing the project and it negatively affects their grades in other courses. Therefore, during the year, the Curriculum Committee adjusted the structure of the course so that the students get enough time to work during the guiding sessions. The MECHATON revealed that the students’ English level needs to be improved. Therefore, in the first course, the students are required to present all the presentations in English and the reverse engineering report must be written in English as well. The MECHATON has proved itself as a successful event, and in addition to the contribution to the students, the department finds many benefits for the faculty. The collaboration with professors from other foreign institutes enriches the faculty’s professional network. Additionally, the collaboration with the industry serves as a breeding ground for doing mutual projects.

REFERENCES

Advantages of the Project-Oriented Teaching Method for Graduates in Mechanical Engineering

I. Horesh\textsuperscript{1,2}, E. Fisher\textsuperscript{3}

\textsuperscript{1} SCE, Department of Mechanical Engineering, Beer-Sheva, Israel, idan.horesh@gmail.com
\textsuperscript{2} IAI RAMTA Plant, South District, Israel, ihoresh@iai.co.il
\textsuperscript{3} SCE, Department of Mechanical Engineering, Beer-Sheva, Israel, etanfi@sce.ac.il

Abstract – An important aspect of project oriented teaching is its impact on the success of graduates in the beginning and during the development of their careers. This paper focuses on the PO courses given in the Mechanical Engineering Department of Sami Shamoon College of Engineering (SCE) in the Mechatronics track. Mechatronics is a multi-disciplinary field of engineering that combines mechanical, electrical, control and software engineering skills with specific industrial applications in automation and robotics. Two courses given by the department in consecutive semesters use the PO approach to apply and develop mechatronic skills. The paper discusses the significance of the acquired skills for success in a challenging engineering position.

Keywords: Mechatronics, Graduate students, Industry experience.

I. INTRODUCTION

Engineering design may be described as the process of devising a system, a component, or a procedure to meet desired needs [1]. Frameworks within which engineering design can be planned and executed include systems engineering, review-based design and project management [2, 3]. These extensive fields are employed to inspire the design process in the PO courses in the SCE Mechanical Engineering Department.

In project management terms, a project is a temporary endeavour having a defined beginning and end and undertaken to meet unique goals and objectives [2]. In project-oriented teaching, the time span may be defined by the length of the semester. The goals and objectives may be defined by the chosen teaching materials on the one hand and success-driven motivation on the other. Project-oriented teaching allows the students to use skills that are not necessarily focused on in formal teaching, such as creativity, motivation by self-expression, and task and projects management.

Furthermore, industry work is often project-based and includes work in teams, budget management, and work with suppliers. In project-oriented teaching, these areas of responsibility are practiced. The students receive a task with basic requirements that need to be completed within a given time limit and must present a final product upon the completion of the processes of managing, developing and manufacturing whilst along the way manage, develop, and manufacture, under the supervision of the teaching staff. The tasks are performed with a view to complete the project simulation tasks that engineers may encounter in future industrial work.

II. THE ADVANTAGES OF PO EXPERIENCE

The two main PO courses in the mechatronics track at SCE Department of Mechanical Engineering are "Design and Development of Mechatronic Systems" (1 and 2). In the first course, students are in charge of developing the electronic and automated controls for a small boat. The boat itself is developed by students from the design track. The main goal of the boat is to deliver food, drink and other small products to vacationers in the Dead Sea. In the second course, the mechatronics students work independently and are in charge of all aspects of engineering and project management. The specific goal is to develop a self-balancing system.
I. Horesh, E. Fisher “Advantages of the Project-Oriented Teaching Method for Graduates in Mechanical Engineering”

The following quotation refers to the experience of the author, I. Horesh: "The project in "Design and Development I" course provided me with practical experience in the development of control systems, working with sensors and developing a motion drive system. This course helped me to properly understand control of systems. Before this course, control experience focused on solving exercises with no real understanding as to the significance of the numbers and results. This course was challenging and exciting and caused a leap in my understanding".

"The second course continues to help me very much to this very day. In the course, we were four students in a group. The goal was to develop an autonomous unicycle that would maintain balance and would not fall down. The members of the group were assigned different engineering roles: Project Manager; Product Design Engineer; Control Engineer; Production Engineer.

I chose the role of product design engineer. At the same time, I started working as a student (and I am currently working as an engineer) on the development of vessels in the aircraft industry. Most of my work was with CAD software. Therefore, I thought that the role of Product Design Engineer would give me experience that would be helpful in my work in the air industry and so it was."
I. Horesh, E. Fisher “Advantages of the Project-Oriented Teaching Method for Graduates in Mechanical Engineering”

During the project, I gained a great amount of knowledge in CAD software. I learned many commands and new functions and designed the unicycle from the beginning to the end. There were a number of changes made during the project due to the problems that arose from difficulties in production. These are the challenges that I face to this day in my current work, and I think that beyond the knowledge and experience I gained from this project, I also received much confidence that helps me in my work today”.

IV. CONCLUSIONS

Students in the PO courses presented here are required to design a product from the beginning stage until its completion. The benefits of this process include the ability to deal with real challenges that students will encounter in their professional careers. Specific advantages include in-depth technical understanding of the production stages and clearer knowledge of production technologies and project management.

PO teaching develops creative thinking and increases motivation and desire to succeed. In addition, it leads to satisfaction and excitement as students succeed in making the final product work.

Finally, the challenges of PO courses are similar to the challenges experienced in the industry. The students receive significant experience during their studies, which facilitates their future professional success.

REFERENCES

A Business Intelligence Project-Oriented Course: A Breast Cancer Research Case

D. Alberg*, H. Ben Shimol, H. Erez Kdusha

SCE, Department of Industrial Engineering and Management, Beer-Sheva, Israel
* dimitria@sce.ac.il

Abstract – The Business Intelligence Project-Oriented Course has been taught at the department of Industrial Engineering and Management since 2016. In this course, the students learn to build websites and business intelligence systems which enable to perform data analysis and research in order to get valuable business insights and to retrieve specific business information. The paper is devoted to BI course implementation in the Department of Industrial Engineering and Management of Sami Shamoon College of Engineering (SCE).

Keywords – Business intelligence, Data visualization, Data dashboards, Data mining.

1. BI PO COURSE IMPLEMENTATION

The proposed project-oriented (PO) business intelligence (BI) course consists of seven frontal lectures and seven personal meetings with students. Specifically, during the first lecture, the course instructor teaches and helps the students to set a project domain and to build relevant data warehouse. Then, in the second lecture, the course instructor teaches the students to design the project's web site and to configure site pages for future BI system dashboards. In the third and fourth lectures, the course instructor teaches the students how to build a business intelligence system in the cloud [1]. In the fifth lecture, the course instructor teaches students how to embed the previously built BI system into the project’s website. In the sixth lecture, the students are taught how to test the system in order to recognize security and systems bugs and fix them. In the seventh lecture, the instructor explains to the students how to publish their BI web system on the Internet, open it for public use and participate in the course Hakathon in order to get overall project rating which is a part of the final grade in the course. From the technical point of view, the students gain the following practical skills during the course:

1. Web Data Connectors design and setup
2. BI System Data Warehouse modelling and construction
3. BI System Data Cubes modelling and construction
4. BI System Dashboards modelling and construction
5. BI System design and implementation
6. BI System setup and construction
7. BI System testing and maintenance

The remaining seven lectures are devoted to personal mentoring, answering of questions and collaboration with the student teams.

In our opinion, all implemented projects are of high practical and research importance for students. During each project, a data warehouse is collected and designed BI system dashboards are opened for public access on the Web. It means that everyone who has access to the project's website, is able to view and download the collected data, analyze the data and get in-depth knowledge from the data with the aid of the previously constructed BI dashboards. This approach allows to easily embed the project results in journal/conference research papers which can serve as a public arena for professional discussion and collaboration.
The course is supported with a vast amount of Moodle materials and specially designed educational SCE BI YouTube videos which assist the students with finding correct solutions of technical problems.

![YouTube videos snapshot](image)

Fig. 1. The snapshot of the SCE BI YouTube educational videos

At the end of the course, the instructor updates and publishes new video materials on the YouTube channel developed by the college.

### 2. EXAMPLE OF PROJECT

The following table demonstrates some of the course projects which were completed in the last course year.

<table>
<thead>
<tr>
<th>Project URL</th>
<th>Project BI System Title</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="https://sites.google.com/view/breastcancerproj/home">https://sites.google.com/view/breastcancerproj/home</a></td>
<td>Breast Cancer BI System</td>
</tr>
<tr>
<td><a href="https://sites.google.com/view/tatw/home">https://sites.google.com/view/tatw/home</a></td>
<td>Terrorism Around the World</td>
</tr>
<tr>
<td><a href="https://sites.google.com/view/got-bi/home">https://sites.google.com/view/got-bi/home</a></td>
<td>Game of Thrones</td>
</tr>
<tr>
<td><a href="https://sites.google.com/view/ronisim/home">https://sites.google.com/view/ronisim/home</a></td>
<td>Tourist Security Information</td>
</tr>
<tr>
<td><a href="https://sites.google.com/view/crimes-in-chicago/home">https://sites.google.com/view/crimes-in-chicago/home</a></td>
<td>Drug Crimes Chicago</td>
</tr>
<tr>
<td><a href="https://sites.google.com/view/olympic-statistics/home">https://sites.google.com/view/olympic-statistics/home</a></td>
<td>סטטיסטיקה奥林פיית</td>
</tr>
<tr>
<td><a href="https://sites.google.com/view/bipro22">https://sites.google.com/view/bipro22</a></td>
<td>תפיסת התאומיה בישראל whether</td>
</tr>
<tr>
<td><a href="https://sites.google.com/view/human--analytics">https://sites.google.com/view/human--analytics</a></td>
<td>ההורים הם בקשר עם הילדים?</td>
</tr>
<tr>
<td><a href="https://sites.google.com/view/moadonitbeersheva/home">https://sites.google.com/view/moadonitbeersheva/home</a></td>
<td>_surveysсת estará ביצירת עניין במשפחה</td>
</tr>
<tr>
<td><a href="https://www.sites.google.com/view/projectbiadiandadir">https://www.sites.google.com/view/projectbiadiandadir</a></td>
<td>מוערבות הורים 세상 עניין ילדות ב봐 תמקם</td>
</tr>
</tbody>
</table>
The Breast Cancer BI System containing data description and BI System Tableau [2] dashboards is shown below. The main goal of the system is to display important information regarding the impact of hormones, body measurements, and different stages of tumor on breast cancer disease. The system was created in order to facilitate a visitor's understanding of the medical terminologies and help him or her learn more about the disease. The system website contains the following pages: Home, Data, Terms Glossary, Breast Diagnosis, Hormones, Physical, Survival, PAM50 mRNA and Story Dashboards.

The Home page (Fig. 2) contains a short description of the system, a visual projection of the female body anatomy with possible breast cancer spread zones. The Data page (which isn't shown here) contains the medical data warehouse used in the project. The Glossary of Terms (Fig. 3) represents the research terminology with definitions of terms, illustrations and filtering.

Fig. 2. BI system home site

Fig. 3. BI system glossary of terms site
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The Breast Diagnosis, Hormones, Physical, Survival, PAM50 mRNA and Story Dashboards (Fig. 3), constructed with the help of Tableau BI cloud system, present research of various aspects of the disease and enable deep investigation and analytical appraisal of the collected medical data.

As we can see, each project is the result of intensive research and technical work. The student's team is confronted with a great number of challenges during the course project. The challenges arise in coordinating teamwork, data warehouse collection and preparation, website design and final BI system building and implementation.

3. HACKATHON

Within the Hackathon, the instructor performs the testing of each project submitted by the students. To estimate the project performance the following parameters are used: system dashboards query response times, systems dashboards complexity, performance and data warehouse coverage metrics etc. Each project results in a final grade according to the previously mentioned parameters. Then, all the projects are sorted according to the final grade and represented on the Hackathon contest site.
The main conclusion is that the students enjoyed being part of the project and implementing all of the course's requirements. We think that the secret of the course is very simple: the students enjoy producing a specific BI cloud system on the Web based on real data. The students learn to work professionally, with professional tools and present their results to other people. Finally, each project course is accompanied by a website address which can be easily copied into a personal CV or other documents.

One of the possible ways to improve the course might be to incorporate more databases and to use additional research methods allowing to publish each BI system site as an autonomous research project.

REFERENCES

Physics Laboratory Teaching in Project-Oriented Environment

E. Plosker, G. Reshes*, L. Oster

*SCE, Physics Unit, Beer-Sheva, Israel
*galina@sce.ac.il

Abstract – This paper describes two methods of teaching a physical laboratory course in PO environment used in the Physics Unit of Sami Shamoon College of Engineering (SCE). The first one includes planning, building and conducting a new experiment. The second one sets the goal to design a new experiment and write a manual.

Keywords - Mechanics laboratory, Project-oriented teaching.

I. INTRODUCTION

Physics is one of the core subjects in engineering studies. As part of physics studies, students take a physics laboratory course. The course helps to understand the material that is learned in theoretical courses. To increase students’ motivation and to make the course more interesting, it was decided to teach it in a PO environment. The main difference between the PO teaching approach and the traditional teaching is the connection between the course and the future profession of the student. In addition, this approach allows a deeper understanding of various physical processes and provides tools for solving real-world problems.

II. PO IMPLEMENTATION

The teaching of the physics (mechanics) laboratory course in SCE in a PO environment is implemented using two approaches. The first approach, which is suitable for civil engineering, mechanical engineering and electrical engineering students, demands the design and performance of an experiment by students. During laboratory work, the students study the theory of a new subject, design an experimental system, construct it and perform an experiment. The second approach, which is more suitable for industrial and management students, demands only the planning of an experimental system without conducting an experiment. An industrial and management engineer should be able to plan process experiments and anticipate the results. Therefore, we think that the PO approach is more suitable for laboratory courses and can help to achieve this goal.

III. EXAMPLE OF PROJECT FOR CIVIL ENGINEERING, MECHANICAL ENGINEERING AND ELECTRICAL ENGINEERING STUDENTS

The experiment performed as part of the PO teaching in the mechanics laboratory is research related to the Doppler effect. The Doppler effect is the phenomenon of changing the observed frequency of a wave that happens due to the relative movement between the source of the wave and the observer. When the transmitter and the receiver approach each other, the reception frequency will be higher than that of the source, and when they move apart, the frequency will be smaller than the transmitted one. In classical physics, where the speeds of the source and of the receiver relative to the medium are lower than the velocity of the waves in the medium, the relationship between the observed frequency $f$ and the emitted frequency $f_0$ is given by:

$$ f = f_0 \left( \frac{v \pm v_0}{v \mp v_s} \right) $$

(1)
The aim of the experiment was to construct a system in which the Doppler effect can be observed and to measure the frequency of the source. A schematic diagram of the experimental system designed by students is shown in Fig.1. The wave source was a smartphone, tuned to emit a single frequency sound. A second smartphone, used as a detector, was in a basket tied to a wire and could make a circular motion. A force sensor, attached to the top of the wire, allowed to measure tension. The basket was released from different heights and the tension of the thread was measured at the moment when the basket passed near the second smartphone. Based on the measurements of the wire tension, it was possible to calculate the speed of the receiver, according to Newton’s second law. In each experiment, the receiver recorded the waves that were emitted by the source. The frequency of the waves was determined using a Fourier transform. From the graph of the received sound frequency as a function of the speed of the receiver (see Fig. 2), the frequency of the sound emitted by the source can be found.

It is worth paying attention to the fact that the experimental system was assembled using improvised means.

**Fig. 1.** A schematic diagram of the experimental system for the Doppler effect measurement:
1 - the source of the wave, 2 - the basket with the receiver, 3 - the force sensor

**Fig. 2.** An example of a graph of the received sound frequency as a function of the speed of the receiver

IV. THE PO LABORATORY FOR INDUSTRIAL AND MANAGEMENT ENGINEERING STUDENTS

The aim of the PO lab for industrial and management engineering students is to design a new experiment and to write a manual of this experiment for other students. The laboratory
work is carried out according to the following stages: during the first two meetings, students carry out already existing experiments. In this way, they get acquainted with the structure of the laboratory and study the process of carrying out an experiment. At the next stage, students receive topics for the development of new experiments and start to work on them independently. They must determine the purpose of the experiment, design the experimental system, and describe the expected results and the way in which the results are processed.

This semester, we are doing a pilot laboratory using this method. The topics suggested to students are: jet movement, the Foucault pendulum, design of a spring with a given constant by parallel connecting of springs in a row, calculation of the universal gravitation constant $G$.

We believe that the design, construction and description of an experimental system will provide students with experience in process planning and scientific writing.

V. CONCLUSIONS

The physics lab has already been taught in a PO environment for several semesters. In our opinion, this method is effective because it helps students to develop skills that are necessary for their work as engineers, such as creativity, ability to analyze a problem and identify and formulate its solutions. In our laboratory conducted in a PO environment, students should both demonstrate the ability to work independently and be able to work as a team, exchanging knowledge and ideas. These demands make it possible for the design and construction of an experimental system produced by students to be implemented during a hackathon.

In the future, we plan to increase the number of groups performing the laboratory work in a PO environment.

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