The PO Approach: What Changes are Required?

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Abstract

The Project Oriented (PO) approach is a new teaching methodology that is part of the active learning approach. This paper focuses on the changes needed from a lecturer in an academic institution who wishes to change their teaching method from the teacher-centered paradigm to the Project Oriented approach. These changes are reflected in the course syllabus. The changes are done mostly in the sections that describe the learning activities and the assessment methods and criteria. The paper describes, via different syllabi of a variety of PO courses, the changes that the lecturer must make in various aspects. The syllabi originated from our institution, in which about 30 percent of the courses were altered to PO courses.

Key Words: Engineering Education, PO approach, syllabus

JEL Classification: C 92, I23
1. Introduction

Most of the teaching in academic institutions around the world is conducted in a teacher-centered paradigm. In most of the courses, the lecturer teaches the material in a frontal, face-to-face manner and the assessment of the students is based mainly on the final exam. The traditional teaching practice is not providing the needed context or sufficient practice for students to develop the skills needed to solve real work problems (Brodie, Zhou, and Gibbons, 2008). In recent years, various attempts have been made by different academic institutions and individual lecturers to change the common teaching approach and make it more attractive and practical for the students (e.g., Hwang, Lai, and Wang, 2015; Lehmann et al., 2008; Smith, Giugliano, and DeOrio, 2018).

In our institution, Shamoon College of Engineering (SCE), which educates undergraduate engineering students, the Project Oriented (PO) approach was chosen.

SCE is an academic college of engineering in Israel, with two campuses: Ashdod and Be'er Sheva. It is the only academic college of engineering in the south of the country, and on both campuses, together, there are about 5,500 students studying for a bachelor's or master's degree. Every year, about 800 graduates join the labor market, and they account for about 15% of all engineers in the Israeli economy. The college trains engineers in a variety of engineering subjects: software engineering, industrial engineering and management, chemical engineering, mechanical engineering, civil engineering, and electrical engineering.

Over the past three years, about 30% of the courses in SCE were altered to support the PO approach. This change had a significant effect on lecturers' tasks and their role in the classroom, which were reflected by a modification of the syllabus of the course (Buswell, 2018).

The PO approach is an active learning approach, like Problem Based Learning, Project Based Learning, Discovery Learning, and Flipped Learning (Karabulut-Ilgu, Cherrez, and Jahren, 2018; Prince and Felder, 2006). The PO environment implements the theoretical materials through competitions and various projects that students are asked to participate in. It requires more intensive work from the students and from the course staff. However, it encourages creativity and innovation, and sparks interest in the class's topics. In addition, most of the projects contribute to the community and industry. Throughout the years of the engineering degree, the difficulty and challenge of the projects increase. The level of study becomes more profound and enables students to apply the knowledge and turn it into an engineering solution at every stage of their studies.

This paper presents the difference between the lecturer's role in the teacher-centered approach and the PO approach. It does so by comparing the "common" syllabus in the teacher-centered approach to the new syllabus according to the PO approach. The paper focuses on the relevant changes that the educators should make in order to change the course structure from
The paper is structured as follows: In Section 2 we display the active learning in engineering studies, focusing on the PO approach. Section 3 introduces the research question and the syllabi that we analyze. Section 4 discusses the results of analyzing these syllabi. Finally, Section 5 contains conclusions and recommendations.

2. Active Learning in Engineering Studies

Engineering faculty do not always understand how the common forms of active learning differ from each other and most of them are not looking for answers in the educational literature (Prince, 2004). Many of the faculty members believe that all forms of learning are basically active, therefore students are actively involved through homework assignments, formal presentations, class exercises, or classroom discussion.

Active learning requires instructional activities, engaging students in doing things and thinking about what they are doing (Bonwell and Eison, 1991). It could include traditional activities such as homework. However, in practice, the active learning is mostly based on activities that are introduced into the classroom and the students' engagement in the learning process.

Active learning is often contrasted to the traditional lecture where students passively receive information just from listening to their lecturer. The student must read, write, discuss, or be involved in problem-solving abilities. By activity participating in all these actions, students are using high order cognitive skills, such as analysis, synthesis, and evaluation. Instruction that involves students actively has been found more effective in improving problem-solving skills or students' motivation than straight lecturing (Felder et al., 2000; Sutherland and Bonwell, 1996). Furthermore, these instructions were found to enhance professional competences (Virtanen, Niemi, and Negvi, 2017).

Freeman et al. (2014) showed that the performance of undergraduate students in science, technology, engineering, and mathematics (STEM) is better when they learn via active learning. They found that the average exam scores of students that participated in active learning were higher by 6% than those of students that learned using the traditional lecturing. Moreover, students that learn via traditional lecturing are 1.5 times more likely to fail than students that learn via active learning.

The challenge is to involve most or all of the students in productive activities without losing meaningful course content or losing control over the classroom.

The unique format of a PO course is based on the assumption that meaningful activities will enrich the students' knowledge and motivation. The traditional class is replaced by a modern approach of self-learning in the methods and times the students prefer (Shmallo and Shrot, 2018). To the best of our knowledge, no studies have been conducted on PO's approach, except for the study of Chassidim, Almog, and Mark (2018), who found that using PO in the
software-engineering studies promoted the special requirements of software engineers, especially the soft-skills, effectiveness of the team-work, and the overall development process of the project. The PO approach is usually based on a major project that accompanies the course throughout the semester. The assessment of the end project is certainly important, but it is also important to focus on assessments of each of the project stages, which enables the meaningful learning that happens throughout the project (Barron et al., 1998).

3. Methodology

3.1 Research Questions

The question of this research is what changes are required from the lecturer in order to convert a course from teacher-centered learning to PO learning.

It is important to note that this paper is focused on the lecturer's point of view, and the changes required from the lecturer only.

3.2 Data

All syllabi have the same structure: course details, aim, learning outcomes, course contents, planned learning activities and teaching methods, and assessment methods and criteria. We present an example for a typical syllabus:

Course Details

Campus:
Department:
Type of Course: Elective/Required
 Discipline:
Level of Course: First degree/Second degree
 Year of Study: First/Second/Third/Fourth
 Mode of Delivery: Face to Face/Project Oriented/Distance learning/Workshop
 Semester:
Prerequisites:
Credits:
Co-Requisites:
ECTS Credit Points:
Language of Instruction:
Lecturer(s):
Work Placement(s): Laboratory/Factory/Workshop/Studio
Teaching Assistant(s):
Date of Approval:
Lecturer(s) Email:
Aim

The purpose of the course is:

Learning Outcomes:
Upon successful completion of the course the students will be able to:

Course Contents – A table with three columns:
Week, Subject, Relevant Reading

Planned Learning Activities and Teaching Methods
Which teaching methods will be implemented?

Assessment Methods and Criteria – Criterion Percent of final grade Comments

Educators that decided to change the "Mode of Delivery" entry in the course's syllabus to PO should focus the syllabus change on the following entries: (i) planned learning activities and teaching methods and (ii) assessment methods and criteria. Since the content of the course does not change, all other requirements remain unchanged.

We demonstrate the changes in syllabi of 5 different courses that take place in two different departments, focusing on the activities and the assessment process.

Table 1: General Information about the 5 Courses.

<table>
<thead>
<tr>
<th>Course name</th>
<th>Department</th>
<th>Semester in degree</th>
<th>Degree</th>
<th>Type of course</th>
<th>Level of converting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information System Analysis &amp; Design 2</td>
<td>Industrial Engineering and Management</td>
<td>5</td>
<td>First</td>
<td>Required</td>
<td>Fully</td>
</tr>
<tr>
<td>Visual Programming</td>
<td>Industrial Engineering and Management</td>
<td>4</td>
<td>First</td>
<td>Required</td>
<td>Fully</td>
</tr>
<tr>
<td>Intelligent User Interface</td>
<td>Software Engineering</td>
<td>3</td>
<td>Second</td>
<td>Elective</td>
<td>Fully</td>
</tr>
<tr>
<td>Artificial Intelligence</td>
<td>Software Engineering</td>
<td>6</td>
<td>First</td>
<td>Elective</td>
<td>Fully</td>
</tr>
<tr>
<td>Algorithm 1</td>
<td>Software Engineering</td>
<td>4</td>
<td>First</td>
<td>Required</td>
<td>Partial</td>
</tr>
</tbody>
</table>

3.2.1 The Course – Information Systems Analysis and Design 2

This course is taught in the Industrial Engineering and Management Department and it is part of the Information System track. It is given in the first semester of the third year. The course prerequisites are the Object Oriented Programming (OOP) course and the Information System Analysis course (in the functional aspect). The course is based on the book: *Systems Analysis and Design: An Object-Oriented Approach with UML* (Dennis, Wixom, and Tegarden, 2015). The aim of the course is to familiarize students with the phases, methodologies, and tools for the development of information systems, based on the OOP paradigms. Specifically, the analysis, design, and implementation phases, implemented in the UML method, including Use Case, Class Diagram, Activity Diagram, and Sequence Diagram.
Comparing the "Planned learning activities and teaching methods" entry in the syllabus before vs. after converting the Information system Analysis and Design 2 course to the PO approach:

**Before**

The course has 3 teaching hours and 1 exercise hour per week that will be taught face-to-face, homework assignments will be submitted in teams of two students, some exercise sessions will be conducted in a computer lab, and all homework assignments will require the use of relevant software (CASE tool).

**After**

The course will be taught in 3 lecture hours, about half of the sessions in the semester. In the remaining half, personal meetings will be held in order to implement the material studied and write a final project for the course. There will also be a weekly exercise hour. The lectures and the practice will be in frontal teaching. Submission of the exercises and the final project will take place in two-student teams. The submission exercises and some of the exercises will be performed in a computer lab. We will use the Microsoft Paradigm software.

The comparison of the "Assessment Methods and Criteria" entry in the syllabus from before to after converting the course Information System Analysis & Design 2, can be found in Table 2.

Table 2: Comparing the "Assessment Methods and Criteria" entry in the syllabus before and after conversion of the course Information System Analysis & Design 2.

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Exam</td>
<td>85% (grade of 56 or higher is a requirement)</td>
<td>None</td>
</tr>
<tr>
<td>Quizzes</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Assignments</td>
<td>15% (100% submission is required)</td>
<td>None</td>
</tr>
<tr>
<td>Reports</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Project</td>
<td>None</td>
<td>5% Project idea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20% Use case</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30% Class diagram</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15% Activity diagram</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15% Sequence diagram</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15% Relational Database</td>
</tr>
<tr>
<td>Participation</td>
<td>80% is required</td>
<td>100% in personal meetings is required</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80% in lectures is required</td>
</tr>
</tbody>
</table>

**3.2.2 The Course – Visual Programming**

This course is taught in the Industrial Engineering and Management Department and given in the second semester of the second year. The course prerequisite is Principles of
programming. The course is based on the book *Visual C# how to program* (Deitel and Deitel, 2016). The aim of the course is to familiarize students with C#.NET language, learning the principles of object-oriented programming in the Visual Studio Integrated Development Environment (.NET platform) to write, test, and debug applications.

Comparing the "Planned learning activities and teaching methods" entry in the syllabus before vs. after converting the Visual Programming course to the PO approach:

**Before**

This course will take place in the computer laboratory. During the course each student will have to submit one mandatory assignment.

**After**

Seven 3-hour sessions will be taught front-end, including practice, in a computer lab for the whole class. In the rest of the semester there will be orientation sessions for the project groups (student pairs), with 15 minutes for a group meeting. During the entire semester and while working on their final project, the students will be required to learn independently by reading the study material and preparing relevant parts of the project according to the requirements that will be published.

The comparison of the "Assessment Methods and Criteria" entry in the syllabus from before to after converting in the course Visual Programming can be found in Table 3.

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Exam</td>
<td>80% (56 grade or higher is a requirement)</td>
<td>60% (56 grade or higher is a requirement)</td>
</tr>
<tr>
<td>Quizzes</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Assignments</td>
<td>20% (100% submission is required)</td>
<td>None</td>
</tr>
<tr>
<td>Reports</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Project</td>
<td>None</td>
<td>40% (grade of 60 or higher is a requirement)</td>
</tr>
<tr>
<td>Participation</td>
<td>80% is required</td>
<td>80% is required</td>
</tr>
</tbody>
</table>

3.2.3 The Course Intelligent User Interfaces

This is an elective course taught in the Software Engineering Department. It is given to students learning for their master’s degree in the first semester of their second year. The course prerequisite is the course Artificial Intelligence. The course's aims are to educate the students about intelligent user interfaces (IUI), the differences between IUI and artificial intelligence, and the differences between IUI and UI.

Before the change to the PO approach the course was teacher-centered, students learned everything in face-to-face lectures throughout the semester, and take an exam in the end. After the change, the number of lectures being taught by the lecturer were cut in half, and in the second part of the semester each student is given a time frame to present their research on a
state-of-the-art IUI system. The students need to research a specific IUI system (of their choice) and analyze it using the tools and based on the indicators they learned in the first half of the course.

Comparing the "Planned learning activities and teaching methods" entry in the syllabus before vs. after converting the Intelligent User Interface course to the PO approach:

**Before**

The course will be taught face-to-face. Three lecture hours will be given each week for 13 weeks, and will cover the course information. You will be given scientific articles on a weekly basis that you are expected to read and understand before each lesson.

**After**

The first half of the course will be taught face-to-face. Three weekly lecture hours will be given for 7 weeks and will cover the basic topics and possible sources for state-of-the-art IUI systems. The second half of the semester (6 weeks) will be conducted from students' presentations regarding their research and analysis of a newly (last 5 years) developed IUI system.

The comparison of the "Assessment Methods and Criteria" entry in the syllabus from before the converting to after in the course Intelligent User Interface can be found in Table 4.

### Table 4: Comparing the "Assessment Methods and Criteria" entry in the syllabus before and after conversion of the Intelligent User Interface course.

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Exam</td>
<td>80% (grade of 56 or higher is a requirement)</td>
<td>None</td>
</tr>
<tr>
<td>Quizzes</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Assignments</td>
<td>20% (100% submission is required)</td>
<td>None</td>
</tr>
<tr>
<td>Reports</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Project</td>
<td>None</td>
<td>10% Selecting an IUI system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20% correct classification of the system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50% analyzing the system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20% presentation in class</td>
</tr>
<tr>
<td>Participation</td>
<td></td>
<td>80% of the second half of the course is required</td>
</tr>
</tbody>
</table>

**3.2.4 The Course Introduction to Artificial Intelligence**

The course is taught in the Software Engineering Department. It is given in the second semester of the third year. The course prerequisite is the Algorithm 1 course. The course is based on the book *Artificial Intelligence: A Modern Approach* (Russell and Norvig, 2016). The course aim is to educate students about the basic algorithm in the field of Artificial Intelligent. It has three parts. The first third of the course is focused on search problems and gaming search problems, the second third is focused on machine learning algorithms, the last third is a brief introduction to a variety of different areas in the field of artificial intelligence, such as: Game theory, Robotic, auctions, and voting problems.
Before the shift to PO the entire course was taught using the teacher-centered approach and the grades were given according to an exam that tested students' knowledge in the basic algorithm and approaches shown in class. After the change the entire curriculum was changed to focus solely on basic algorithms, and information on how to approach a scientific research paper. More reception hours were given to the students during the semester and the exam was replaced with a final project. During the course, students were directed to use the basic information given in the class in order to extend their knowledge to the state-of-the-art development in each of those fields in the Artificial Intelligence research. In their final project students were directed to develop a state-of-the-art solution to a problem in one of the areas covered during the course.

Comparing the "Planned learning activities and teaching methods" entry in the syllabus before vs, after converting the Artificial Intelligence course to the PO approach:

**Before**

The course will be taught face-to-face. Three weekly lecture hours will be given each week for 13 weeks, and will cover the course topics.

**After**

The course will be taught face-to-face. Three weekly lecture hours will be given for 13 weeks and will cover the basic topics and possible sources for in-depth learning of state-of-the-art algorithms and developments. Students must come up with an AI problem they wish to resolve and meet the lecturer in the receptions hours in order to discuss and agree about the problem and state-of-the-art solution they will apply to it.

The comparison of the "Assessment Methods and Criteria" entry in the syllabus from before the converting to after in the course Artificial Intelligence can be found in Table 5.

**Table 5: Comparing the "Assessment Methods and Criteria" entry in the syllabus before and after conversion of the Artificial Intelligence course.**

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Exam</td>
<td>80% (56 grade or higher is a requirement)</td>
<td>None</td>
</tr>
<tr>
<td>Quizzes</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Assignments</td>
<td>20% (100% submission is required)</td>
<td>None</td>
</tr>
<tr>
<td>Reports</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Project</td>
<td>None</td>
<td>10% Selecting an AI problem</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50% Analyzing the problem</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40% Applying a state-of-the-art solution</td>
</tr>
<tr>
<td>Participation</td>
<td></td>
<td>80% enable 5-point bonus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Students must attend at least 2 personal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>meetings during reception hours.</td>
</tr>
</tbody>
</table>
3.2.5 The Course Algorithms 1

The course is taught in the Software Engineering Department. It is given in the second semester of the second year. The course prerequisite is Data Structure, and it is based on the book *Introduction to Algorithms* (Cormen et al., 2009). It has two parts: In the first part the students advance their understanding of asymptotics and several advanced data structures. In the second part they learn the methods of greedy algorithms and dynamic programming.

Before the change the entire course was teacher-centered and the grade was given according to homework and an exam. After the change a "hakathon" was added to the course, in which the students are divided to groups of 3 or 4 students, and in a period of 3 hours they need to solve a problem using a greedy algorithm or dynamic programming.

Comparing the "Planned learning activities and teaching methods" entry in the syllabus before vs. after converting the Algorithm 1 course to the PO approach:

**Before**

The course will be taught face-to-face. The lecture is 3 hours and the TA class is two hours. The homework will be done independently.

**After**

Twelve of the thirteen classes will be taught face-to-face. The lecture is 3 hours and the TA class is two hours. During the TA class session, the students will attempt to solve problems on their own and in pairs. The homework will be done independently. In the last class the students will be divided to groups and attempt to solve a new problem using methods taught in the course.

The comparison of the "Assessment Methods and Criteria" entry in the syllabus from before to after converting in the course Algorithm 1 can be found in Table 6.

Table 6: Comparing the "Assessment Methods and Criteria" entry in the syllabus before and after conversion of the Algorithm 1 course.

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Exam</td>
<td>90% (grade of 56 or higher is a requirement)</td>
<td>75% (grade of 56 or higher is a requirement)</td>
</tr>
<tr>
<td>Quizzes</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Assignments</td>
<td>10% (100% submission is required)</td>
<td>None</td>
</tr>
<tr>
<td>Reports</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Project</td>
<td>None</td>
<td>25%</td>
</tr>
<tr>
<td>Participation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Results and Discussion

From our experience and from the example syllabi we showed, it is apparent that the conversion of courses from teacher-centered learning to the PO approach involves various changes to the lecturer.
First, the lecturer's state of mind should change. Meaning, the conceptual understanding that even though he is not standing in front of the class and transferring information, he is still the leader of the learning process and still has as much influence as before on the learning processes of his students. Furthermore, in the PO approach the lecturer's conduct is as important as in the teacher-centered learning.

Second, the focus of the lecturer's task should be changed. As seen from the presented syllabus in teacher-centered learning, the main tasks of the lecturer are preparing lectures, writing assignments, and a final exam. In the PO approach, although the lecturer also needs to prepare lectures, the main focus is on creating various learning activities, such as project, assignment, hackathon. Since the learning is conducted from these activities, there is a need to structure them carefully. The activities should be based on increasing cognitive skills and problem-solving abilities in a way that the students will actually learn from them. For example, if it is a team project then the lecturer should make sure the work spreads over all the team; if independent learning is needed, then the lecturer should direct the student how to apply the material properly when necessary.

As described in Freeman et al. (2014), although active learning is effective for all class sizes it is most effective on small groups. Hence, in order to implement the PO approach in our institution, the class is divided into small groups. The course staff, including the lecturer, have personal meetings with 2-3 students in each group in order to discuss the products of the activities with the students. There are several meetings during the semester. During the meetings, the students can ask questions about the materials they learned independently, the correctness of the implementation of the material studied, and brainstorming for problem solving and more. It demands a large portion of their time from the lecturer. Yet, it creates a different relationship with the students. The lecturer gets to know the students' abilities and skills better and from different aspects. Thus, this can make the learning process more accurate for them.

Another task the lecturer needs to do in PO approach is to evaluate many small tasks that students should do during the various activities. Instead of checking the final exam at the end of the semester, he or she must create and examine a significant number of assignments, depending on the size of the class, during the entire semester. Furthermore, the students' answers to a certain assignment or activity will usually be less coherent, and structured in a less elegant way than the lecturer would have done. This demands that the lecturer preserve an open mind in order to see the underlying logic. Although it is not easy to accomplish, from our experience the students sometimes have a new refreshing way of looking at the assignment. This again means more work and time for the lecturer. However, as mentioned, it makes the relationship between the student and lecturer more meaningful.
We listed some needed changes in the transformation from teacher-centered learning to the PO approach. Looking at the syllabus of Information Systems Analysis and Design 2, in Section 3.2.1, the teaching methods and the assessment process have completely changed. However, it does not have to be done all at once. The syllabus of the courses Artificial Intelligence shown in Section 3.2.4 and Algorithms 1 shown in Section 3.2.5 are examples of courses that combine aspects from both learning paradigms. Hence, it is a less demanding conversion.

5. Conclusions and Recommendations

There has been much research concerning active learning and its advantages over teacher-centered learning. This encourages institutions and lecturers to transform courses from one paradigm to the other.

We showed via syllabi the main changes that such a transformation entails. The courses we showed were of two departments: Software Engineering and Industry Engineering and Management. We present different types of PO courses in order to show the various ways of changing. Some of the courses are more theoretical and some more practical. The change in the syllabus is done in the sections that refer to learning activities and assessment. This is crucial since only the learning process needs to undergo a change, but the content of the course must stay the same.

In light of the changes in the syllabus, we discussed the changes in the course from the lecturer's perspective. The changes in the lecturer's state of mind, the type of relationship with the students, and the shift in the focus of the lecturer's job and time.

One can see from our list of changes that transforming a course to the PO approach demands a great deal of work and time from a lecturer. However, from our own experience, it seems worthwhile.

References


