‘A CUSTOMER COMES WITH A PROBLEM…’ A PRACTICAL APPROACH TO PROJECT CLASSES

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Abstract

The paper describes a practical approach of conducting project classes. The proposed method allows for introducing a typical customer-contractor cooperation. While the typical projects realized by students focuses on calculations, the approach at hand puts the accent on gathering the data and discussion between customer and contractor (student). The proposed way is much more demanding for students. It forces them to learn how to talk to a customer and to search actively on how such problems can be solved. As the project is finalized with oral presentation of its outcome, also the presentation skills and stress resistance increase. At the same time such handling of project classes is more demanding and time consuming for the lecturer. Here preparation of a single problem and project supervising require significant effort. The effort that pays off as the students can learn how to handle real case problem and learn how to use knowledge and skills gained during previous semesters of education.

Keywords: Keywords: Problem based learning, technical studies, practical approach.

1 INTRODUCTION

There is a traditional way of conducting project classes that was used ever since I was a student. First, the task is explained in details. Due to the fact that group of students counts between 8 to 16 students projects are done by single student or by teams of 2-3 people. Next, all necessary equations or mathematical models are delivered to project participants. Thus, main task is limited to performing mathematical calculations. The advantage of such approach is that physical mode used for solving the problem may be quite complex. Results of such project are presented in a report. For such formulation of the classes students learn how to solve a problem, but not why such approach/model was used and how the data for problem solving was found. Thus, a different approach was proposed. The proposed approach was based on Project Based Learning technique [1], [2], [3]. Here, the lecturer fills role of a customer that comes to the engineering company with a problem to be solved [2]. Of course the level of difficulty of the task has to be carefully selected so the students can meet its requirements. The complexity of the physical models has to be lower than for classical approach due to the fact that other activities are to be done by students. Project is divided into several phases. During first phase, a customer presents brief description of the problem to be solved and a desired results he wants to obtain. As, at this moment, more problems are presented in front of whole group, the students can rival between each other to work with the subject they desire the most. When a problem is assigned to student there is a discussion where more information is given to the students. The second phase is a negotiation one. There, students ask questions about the problem to obtain all the necessary information. The customer often asks back how a desired parameter may be obtained. Simultaneously to negotiations the students build a mathematical/physical model and solve the task. As the solution proceeds new sub-problems are revealed. When the problem is solved last phase begins. Here students prepare a short summary and deliver a presentation in front of whole group. All of the projects done with students are based on actual cooperation between me or my colleagues and the industry. Thus students have the opportunity to face real life problem [3].

2 METHODOLOGY

To describe the proposed approach a sample project will be presented. The presented project is realized at second semester of MSc level at the Faculty of Energy and Environmental Engineering. The main theme of project is heat and mass transfer and numerical methods. The task to be done is to solve energy balance for a given engineering problem using analytical and two numerical methods. Students involved in project are familiar with heat and mass transfer at the level required by project while the theory regarding numerical methods are provided at the lecture associated with project
classes. The time frame for project is 9 classes' hours i.e. 4 meetings at 90 minutes plus one at 45 minutes.

The classical approach involves:

- introduction and project assignment – 30 minutes (1st meeting)
- explanation of mathematical background and necessary equations – 45 minutes (1st meeting)
- discussion/questions – 15 minutes (1st meeting)
- problem solving – 3x90 minutes (2nd 3rd and 4th meeting)
- report preparation – 45 minutes (5th meeting).

There the students follow a linear path. The project timeline shows main focus on computations. The typical task given to students is formulated as follows:

**Project general information:**

*The task is to find the temporal variation of temperature by solving the non-dimensional transient heat conduction equation. Investigate the effect of the material properties (density, heat capacity) as a function of temperature on the result. Solve the problem analytically (as an energy balance for average values) and numerically with Euler and middle-point techniques. Determine the influence of the step length on the result.*

**The report should contain:**

- figure illustrating problem
- boundary and initial conditions
- analytical solution for constant parameters
- graphs of density and heat capacity functions of temperature
- results with temporal history of temperature
- conclusions
- graphical comparison of solution for three step lengths
- conclusions

Report has to be sent together with calculation file where the task is solved.

**Deadline:**

Grade: weighted average of: calculations 60%, report 40%.

**Description of numerical methods required in the project:**

**Lecture notes at:** https://platforma.polsl.pl/rie/pluginfile.php/10880/mod_resource/content/1/M2_3.pdf

**Detailed information on energy balance and heat transfer:**


**Project description:**

*Determine the time at which the room of dimensions 5x5x2,5m (walls, floor and ceiling are made of bricks of conductivity equal to 0.45 W/(mK) and thickness of 0.5 m) and an initial temperature of 7°C will heat up to 20°C. The room is heated with an electric heater of power of 3kW. The heat transfer coefficients inside and outside the room are constant and equal to 2.1 W/(m²K) and 6.3 W/(m²K) respectively. Consider the influence of the temperature on density and specific heat of air. The room is surrounded by other rooms (two walls), basement (floor) and ambient air (remaining walls and ceiling). Indoor temperature is 20°C while outside temperature is -10°C. Assume that the heat is lost to the environment only by convection. There is about 3% volume of wooden furniture inside a room that due to their heat capacity influence the heating time.*

As one can see all necessary information regarding model and data for computations are provided explicitly. The newly proposed approach modifies the information given to students. The time plan needs to be modifies and for ‘customer’ approach is as follows:
Students obtain the following information:

**Project general information:**

The task is to find the temporal variation of temperature by solving the non-dimensional transient heat conduction equation. Investigate the effect of the material properties as a function of temperature on the result. Solve the problem analytically (as an energy balance for average values) and numerically with Euler and middle-point techniques. Determine the influence of the step length on the result.

Short summary (max 1 page A4 size, font 12) in pdf format has to be sent together with calculation file where the task is solved (xls, ees, m etc.).

**Deadline:**

Grade: weighted average of: calculations 35%, report 35% presentation 30%

**Description of numerical methods required in the project:**

Lecture notes at: https://platforma.polsl.pl/rie/pluginfile.php/10880/mod_resource/content/1/M2_3.pdf

**Detailed information on heat transfer:**


**Project description:**

There is a wooden one-storey cottage situated in the Bieszczady mountains. The cottage is equipped with an automatic gas heating system controlled via the GSM network. The company that rents the cottage produced mobile application. Thus the company needs to know the time it takes to heat the cottage up, so that the tenant knows how much time ahead to issue a gas boiler start command when he wants to go to the cottage. The house is used for the entire year.

There are several key differences between classical and newly proposed approach. The most obvious one is the formulation of the project details. For the newly proposed method there are no values given in the initial phase to students. Instead they receive the description of a practical problem. The idea is to focus them on how to approach the presented case. Main challenge is that this is no what-if case study but all ideas have to be supported by engineering calculations. All necessary details are described in the backstage notes of the lecturer and are revealed during negotiation phase. To simplify mathematical model students are allowed to use Christiansen radiation model and to compute heat transfer coefficients from simple engineering formulae. The time devoted to problem solving is the same with the exception of time spent on negotiations. Second most important improvement is a change from long report to short summary. The key point here is to teach student how to select the most important information/results and to briefly formulate their thoughts.

### 2.1 Phases of the project

As for most of the students this is their first contact with such type of classes at the beginning there is a short introduction that describes how the cooperation will look like and what are lecturer expectations from students. There is a possibility to handle about 5-6 projects during classes, thus students are divided into teams. Next, the description of each project is read in front of all teams. The project is assigned to a team which first announces readiness to handle such task. If, after presentation of all problems any of the teams does not have a project assigned, their task is selected randomly from remaining free projects. This mimic a real situation on the market where very often decision have to be made fast. After all projects are assigned students have time to read problem description and ask any questions regarding their problem to solve. The discussion on what is important for a given task and how students should start concludes first meeting.
Second meeting starts with negotiations. Students prepare their questions before classes and have the time to discuss problem with lecturer to obtain more detailed information on the analysed case as well as the data needed for calculations. As an example for above mentioned house heating case detailed information encompasses:

- weather environment (the location is sunny and hidden from wind, cottage is used mostly during summer and winter, during spring and fall due to heavy rains the cottage is rarely used)
- materials (walls made of oak wood plates of thickness 0.2 m, insulation of 10 cm Styrofoam 10, inside wooden furniture, windows covered with blinds)
- ventilation (natural, not closed during vacant period i.e. causes heat losses)
- heating (power of the boiler, localization of heater)
- energy balance (importance of convection and radiation, accumulation of heat inside walls an furniture etc.)

Negotiations are the most important and interesting part of classes. Sometimes student present very unconventional approach to the problem which results with non-typical solution. This is most demanding for a lecturer but also most rewarding. This causes deviation of the task from the path assumed by lecturer and sometimes leads to unforeseen problems that are solved together by students and lecturer. Parallel to negotiations student build and solve their heat transfer model. During that phase whenever there is a data missing further negotiations take place. At this point students realize that not all of the required data are known or can be measured. Thus a discussion on what can or needs to be assumed and on which basis. This is especially important as up this point most of the students think that engineering work is mostly mathematics. Another important aspect is that students realize that there is a need do perform analysis of the influence of an assumed parameter on the result. The mark given for calculations are affected by the quality of negotiations, completeness of the gathered data and quality of mathematical analysis. When at some point (usually when 50% of time devoted to students work passes) students miss some key data this is explicitly given. This of course affects mark given for this part of the project, but this concerns only the most important parameters/features. Such situation is an evidence of lack of some basic knowledge and identifies very serious problem that needs to be sorted out by student and teaching staff. At this point student is offered an individual help with overcoming this difficulty. Fortunately such situations occur very rarely.

When all parameters required by customer are calculated students have to prepare short summary of their work. The key point here is to focus them on the most important results and conclusions. In classical approach, where there were no limitations on report content the papers delivered by students were extensively long and contained a lot of unnecessary theory (books repetitions) or wordy descriptions. My experience from work for the industrial partners shows that deliverables have to be concise and that the most important part of report is the conclusions. Thus short summary is limited to one page A4 size. Students are informed that correct calculations are enough to pass but in order to mark the highest grade high level of conclusions have to be delivered. The mark for this phase depends on completeness and readability of the report and conclusions level.

The work is finalized by presentation. There the time is limited to 5 min per team which forces selection of the most important information as well. Each student has to answer question asked either by lecturer or another student. The mark given for presentation depends on the technical level of presentation itself and also on oral skills presented by student. During presentation an individual written assessment of the performance is filled up by lecturer. Last 45 minutes is devoted to presentation feedback. Then students are informed on what improvements can be made for their presentation and on their strong points. This is done in front of entire group so everyone can take advantage of the feedback and use it to improve their skills.

### 3 RESULTS AND STUDENTS FEEDBACK

This method was implemented in academic year 2016/2017 and since then was expanded to several courses conducted at Institute of Thermal Technology. Since academic year 2014/2015 each course conducted at Silesian University of Technology is evaluated by students in anonymous survey. Additionally I am performing additional anonymous surveys where more detailed questions regarding conducted projects are asked. The classical approach was less time consuming and required less effort from lecturer. Students evaluated such classes at about 81% score based on 54 surveys. Their main positive comments were connected to cohesion of the given task and readiness for help and
problem explanation as well as the lecturer availability beyond classes. They often comment classes as solid. Main shortcoming of the project was its linearity i.e. there was only one way to solve a problem. The customer approach was developed to meet their requirements. It was designed to help students think out-of-the-box, to reject linearity and give students freedom in exploring their knowledge when finding result. First surveys were very positive. Over 95% of students stated that newly proposed approach is better than classical one. Feedback revealed some necessary improvements regarding the project content and complexity. Overall score for first group of students was 87%. That was encouraging and thus in the following years method was improved especially in terms of handling negotiations and tailoring projects to be more cohesion and mathematical complexity. This turned out to be crucial as the time devoted to project was constant while students had many more things to do than in classical approach. In the following year classes were evaluated by 85 students and achieved 93% score. Nearly 98% of students confirm the superiority of the customer approach. Many students state that this project is challenging but allows for consolidate knowledge and prove themselves in the face of real life situation. One word to describe project is great or unconventional. Some of the students state that the project requires too much work or that preparing both summary and presentation is unnecessary. However those disadvantages are consider minor. Since first introduction of the proposed approach students get involved in the project very much. Average grade obtained by students is 92%. Such high grades reflect their involvement and the desire to perform well in real situation.

4 CONCLUSIONS

The proposed approach was introduced as an answer for the demand reported by students in anonymous surveys. The main advantage of the proposed approach is that it mimic the real situation. There a customer comes to a company that has to solve his problem. This mimic an actual situation on the market where there is an obligation of the contractor to obtain all the data from a customer. The important thing is, that the customer is not an expert in the analysis field and very often also is not an engineer but a businessman. Thus he may not realise what is necessary to obtain the desired project outcome. Presented approach is much more demanding and forces students to learn how to talk and negotiate with a customer. It also requires that students search actively on possible problem solution that can be applied, which equations can be employed and which simplifications can or have to be made. Presenting the outcome of the project in front of everyone has several benefits. First it raises the presentation skills and stress resistance as during the presentation customer and other students may ask questions regarding performed work. Second advantage is that all students see how other problems were solves and what difficulties needed to be overcome. The advantage of the customer approach is confirmed by both high marks obtained by student and grades received in anonymous surveys. The method at hand was presented at the internal meeting of the Institute of Thermal Technology so other lecturers had the opportunity to learn how it works and to adapt the approach for other courses.

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REFERENCES

