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Problem Based Learning in Engineering Education: Meeting the needs of industry

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Problem Based Learning in Engineering Education: Meeting the needs of industry

Summary

Industry hires engineers primarily for solving workplace problems; consequently problem solving skills are an essential part of an engineering education. However, industry problems, as well as the environment engineers work in, are often quite different than what students experience at universities. This workshop explores problem based learning, the differences between problems students typically solve in the classroom and the workplace, as well as the strategies for making classroom problems emulate real-world workplace problems. As the main goal of engineering education is to prepare students for work in industry, closing the gap between classroom and workplace problems will result in better prepared graduates.

Keywords

problem based learning, workplace problem, problem solving skills

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Problem Based Learning in Engineering Education: Meeting the Needs of industry

SUMMARY

Industry hires engineers primarily for solving workplace problems; consequently problem solving skills are an essential part of an engineering education. However, industry problems, as well as the environment engineers work in, are often quite different than what students experience at universities. This workshop explores problem based learning, the differences between problems students typically solve in the classroom and the workplace, as well as the strategies for making classroom problems emulate real-world workplace problems. As the main goal of engineering education is to prepare students for work in industry, closing the gap between classroom and workplace problems will result in better prepared graduates.

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LEARNING OBJECTIVES

By the end of this lecture participants will be able to:

- Identify advantages and disadvantages of problem based learning in engineering education.
- Identify factors that distinguish workplace problems from typical classroom problems.
- Implement strategies for making classroom problems emulate real-world problems to help students develop problem solving skills necessary for work in industry.

REFERENCE SUMMARIES

Jonassen D., Strobel, J. & Lee, C. B. (2006). Everyday problem solving in engineering: lessons for engineering educators. *Journal of Engineering Education*, 95(2), 139-151.

As a key job of engineers in industry is to solve a variety of problems, Jonassen et al. investigate the differences between traditional problems that students solve in the classroom (classroom problems) and problems engineers solve in the 'real' world – workplace problems. Performed qualitative studies identify a variety of attributes that distinguish workplace problems from typical classroom problems with the most significant ones being:

- Workplace problems are ill-structured. Practicing engineers are commonly dealing with incomplete information.
- Workplace problems may be combinations of structured problems.
- Workplace problems have multiple, conflicting goals.

- There is no one, single good way to solve the problem. Often different ways need to be considered and/or applied.
- Most constraints are non-engineering.
- Workplace problems are often solved through collaboration

To better prepare engineers for industry, Jonassen et al. suggest that in the classroom students should solve the problems that have at least some of the characteristics of the workplace problems they have identified.

In the workshop, students will brainstorm about the differences between workplace problems and traditional classroom problems. The lecture following the brainstorming session will present the research findings of Jonassen et al. and relate them to the workshop participants' view.

Arlett, C., Lamb, F., Dales, R., Willis, L. & Hurdle, E. (2010). Meeting the needs of industry: The drivers for change in engineering education. *Engineering Education: Journal of the Higher Education Academy*, 5(2), 18-25.

The main research question this study addresses is 'How can we enhance a sustainable world-class higher education engineering sector that meets the graduate recruitment needs of industry?' In particular, this study explores motivation factors for change towards project and problem based learning and 'experience-led degrees,' exploiting six case studies involving engineering departments across England. Identified similarities in motivation for change across universities can be summarized:

- Decrease drop-out rate
- Improve students' motivation
- Emphasize institutional profile
- Facilitate development of new competences.

How change is implemented varies depending on the institutional profile, mission and priorities. Arlett et al. recognize that the change responsibility does not lie solely on universities, but needs to be shared between universities, industry and the founding bodies.

The findings of Arlett et al regarding motivation for change towards project and problem based learning will be used to facilitate class brainstorming about advantages/disadvantages of problem based learning. Their observations on how the change was implemented in different institutions will be part of addressing strategies for creating classroom problems emulating workplace problems.

Yadav, A., Shaver, G. M. & Meckl, P. (2010). Lessons learned: Implementing the case teaching method in a mechanical engineering course. *Journal of Engineering Education*, 99(1), 55-69.

This study investigates the impact of case-based teaching in a mechanical engineering course in regards to two aspects:

- Students' conceptual understanding
- Students' attitudes towards the case teaching method

The results of the performed experiment showed:

- There was no significant difference in conceptual understanding between students taught using lecture style teaching and students taught using case teaching methods. Authors recognize that this may be caused by how the case studies in their experiment were implemented.
- Case studies increased students' engagement and added realism to the class.

Even though the study did not demonstrate increased conceptual understanding, it showed the benefit of the case teaching method in regards to student engagement which authors believe should decrease the drop-out rate.

In the workshop, the findings of Yadav et al. will be used in a discussion on the advantages/disadvantages of problem based learning. Their example will illustrate how the implementation of problem based learning has a significant impact on the learning outcome.

Lamancusa, J. S., Zayas, J. L., Soyster, A. L., Morell, L. & Jorgensen, J. (2008). The learning factory: Industry-partnered active learning. *Journal of Engineering Education*, 97(1), 5-11.

Learning Factory is an active learning approach where students solve real world problems working in interdisciplinary teams in close collaboration with industry. Its mission is to integrate design, manufacturing and business into engineering education. Learning Factory concepts include:

- Active learning facilities – facilities dedicated to students' hands-on experience
- Cooperation with industry through advisory boards
- Lectures by practicing engineers
- Industry sponsored projects
- Practice based curriculum balancing theoretical and practical knowledge

The study of Lamancusa et al. describes the implementation of Learning Factory concepts in The Pennsylvania State University and University of Puerto Rico-Mayaguez as well as the lessons learned from the implementations.

In the workshop, Lamancusa et al. Learning Factory concepts and observations on their implementations in the two universities will be part of the lecture on strategies for creating classroom problems emulating workplace problems.

Content and Organization

Total duration: 90 minutes

Duration	Subject	Activity	Purpose
5 min	Why 'Meeting the needs of industry'?	Lecture	Raising the awareness of the role of industry in engineering education
5 min	Problem based learning	Lecture: <ul style="list-style-type: none"> • What is problem based learning: • Main goal of problem based learning – increase conceptual understanding 	Clarifying what is considered problem based learning as the use of the term is very different among different authors
10 min	Problem based learning benefits	Class brainstorming: <ul style="list-style-type: none"> • Besides the leaning outcome, what else are advantages/ disadvantages in comparison to lecture style teaching? Focus on engineering education. • What are the challenges? 	Participants will recognize that besides acquiring knowledge and understanding concepts there are other significant benefits of problem based learning.
5 min	Classroom problems and workplace problem	Lecture: <ul style="list-style-type: none"> • What is the traditional classroom problem and what is the workplace problem • Developing problem solving skills 	Clarifying what is considered traditional classroom problem and what workplace problem. This will prepare workshop participants for the next group activity.
10 min	Differences between classroom problems and workplace problem	Group activity: Participants are divided into groups of three or four, making sure that each group has participants from different disciplines within engineering. Groups work on identifying characteristics of workplace	Participants will be challenged to think as a practicing engineer and attempt to find why solving problems in the classroom is not the same as solving industry problems.

		problems which make them different from typical classroom problems. Groups remain the same through the remainder of the workshop.	
5 min	Differences between classroom problems and workplace problems	Class discussion: Groups share their findings with the remainder of the class	Participants will recognize the variety of differences between workplace and classroom problems.
10 min	Differences between classroom problems and workplace problems	Lecture: <ul style="list-style-type: none"> Differences between classroom and workplace problems as identified by Jonassen et al. 	Familiarizing participants with the research findings.
15 min	Including characteristics of workplace problems in engineering education	Group activity: Groups need to come up with a way(s) to bring the elements of workplace problems into the classroom. Examples need to be concrete and specific. If the group wants to bring ill-structured problems into the classroom, an explanation on how to do it is needed.	Groups will realize that there are many different ways to bring workplace problems into the classroom. Even with known characteristics that we want to implement, setting up the problem is challenging and may require involvement of different departments, community or industry.
10 min	Including characteristics of workplace problems in engineering education	Class discussion: Groups share their findings with the remainder of the class	Seeing variety of possible solutions
10 min	Classroom problems emulating workplace problems	Lecture: <ul style="list-style-type: none"> Strategies for creating classroom problems emulating workplace problems Students receive a handout with tips for making engineering classroom problems 	Introducing participants to a variety of strategies for incorporating workplace problem characteristics into the classroom.

		emulate workplace problems	
5 min	Summary and conclusions	Lecture	Review of the workshop

Presentation Strategies

Presentation styles are included in the Organization and Content table and include lecturing, class discussions and group work. Lecturing is primarily used to clarify the meaning of different concepts such as problem based learning and workplace problems. This is done with the purpose of avoiding misunderstandings during group work. Lecturing is also used to familiarize students with research regarding differences between classroom and workplace problems as identified by Jonassen et al..

The two main group activities are built around classroom and workplace problems. The first one deals with identifying the differences between the two and the second one builds on the first one by finding ways to use identified differences in the classroom. Each group activity is followed by a short session where groups share their findings with the class. Class brainstorming is used to identify participants' opinions on problem based learning advantages and disadvantages.

Tips for making engineering classroom problems emulate workplace problems

Creating classroom problems that emulate workplace problems requires the instructor's dedication and willingness to put in additional effort and time. However, it results in students being better prepared for work in industry.

Problem	Goals
Incomplete information – providing information upon students' requests.	Design classroom assignments without giving students complete information. The goal is for the students to identify missing pieces and try to acquire them.
Incomplete information – information not available upon students' requests.	The goal is for students to learn to work with missing information. It forces them to search for different solutions and to estimate design parameters or any other missing information.
Multiple, conflicting goals.	Workplace problems commonly have multiple goals, often conflicting, such as quality of the supplied solution or product, cost, timeframe, resources, environmental impact and others. The goal of designing classroom assignments with conflicting goals is for students to learn to prioritize and balance.
Problems that can be solved in different ways.	In textbook problems there is typically a preferred way of solving the problem while in workplace problems there are often multiple solutions. Students need to recognize the existence of possible solutions, analyze them and establish criteria for choosing the final solution. The goal is not to find the optimal solution, but to teach the process of finding a near optimal solution in a limited timeframe.
Include non-engineering constraints.	Examples of such constraints are: environmental, political, legal, cultural and fitting within a specific company corporate culture.
If possible design problems that will require skills distributed among team members.	Solving such a problem requires extensive collaboration between team members, which is an integral part of the engineering work environment.
Unanticipated problems	Real life problems are dynamic—constraints, conditions, and goals may change during the project. Introducing changes in the middle of the project may not make students happy at first; however, it will teach adaptability and prepare them for work in industry.
Whenever possible use real industry problems in the classroom.	Solving the 'real world' problems gives engineering students additional motivation and prepares them for future work in industry.