Beyond the "Right" Answer: Motivating Students through Problem-Based Learning

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Objectives

- Develop a clear understanding of Problem-Based Learning (PBL) & how it can be applied to Chemical Engineering.
- Understand factors influencing PBL effectiveness.
- Explore the effect of PBL on student motivation.

Problem-Based Learning (PBL)

What is PBL?

- Active-learning exercise(s) based on authentic, ill-conditioned problem(s).
- Student-centered approach (often collaborative), where instructors act as facilitators rather than lecturers.
- Implementation techniques vary, and may include various degrees of scaffolding (lectures, student check-ins, etc.)
- Problem type may also vary, from straightforward calculations to troubleshooting to design problems with no "right" answer.

PBL Applications in Chemical Engineering

- Create links between classroom & workplace.
- Encourage students to focus on problem-solving process.
- Present diverse subjects within problems.
- Incorporate technology (quizzes, virtual labs).
- Develop soft skills (teamwork, communication, etc.)

PBL in Chemical Engineering

Rossiter et al. (2010): blended-learning PBL (formative online quizzes to supplement lecturing)

Koretsky et al. (2011): project-based learning (industrially situated virtual laboratories)

Woods (2012): "authentic" PBL (weekly open-ended challenges, no lectures)

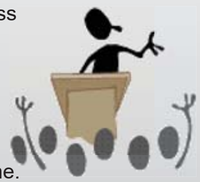
Nielsen et al. (2016): project-organized PBL (beer-brewing pilot plant as learning platform)

Learning Environment + Student-Related Factors = Effective PBL

Learning Environment

Instructors / Facilitators

- Instructors act as facilitators; their effectiveness can dictate the success of the course.
- Instructors:
  - Must understand & relay benefits of PBL.
  - Must provide guidance with minimal intervention (balanced approach).
  - Must be willing to move beyond comfort zone.



Problem Selection & Assessment Techniques

- PBL Problems:
  - Should be ill-conditioned and open-ended.
  - Should have real-world applications.
  - Should be of an appropriate degree of difficulty.
- Assessment Techniques:
  - Must align with learning outcomes (knowledge & skills).
  - Must focus on problem-solving process, not factual recall.
  - Must provide opportunities for students to succeed.

Student-Related Factors

Personal Situation, General Interest & Ability

- Personal Situation:
  - Prior knowledge, course schedule (time management), home life, etc.
- Student Interest:
  - Situational interest is related to engagement in instructional activities & student enjoyment; related to learning environment.
  - Individual interest is difficult to measure (much less influence), as it is linked to personal values.
- Ability to Succeed:
  - Studies show that students are more motivated when they believe they have the ability to complete the assigned tasks, and when they see benefits from successful completion.

Effective PBL: Student Motivation

Student Motivation

- When students are motivated, they take responsibility for their own learning.
  - Extrinsic Motivation: influenced by external factors (approval from others, grades, etc.)
  - Intrinsic Motivation: largely linked to student-related factors; influenced by personal satisfaction.
- Motivation is student-specific, and is typically measured by critical reflection & self-evaluation.

MUSIC Model of Academic Motivation

- From Jones (2009), students are more motivated…

M	• …when they feel **eMpowered**. • Motivating opportunities in decision-making.
U	• …when content is **Useful**. • Ill-conditioned problems with real-world applications.
S	• …when they believe they can be **Successful**. • Careful problem selection & reasonable assessment.
I	• …when there is situational & personal **Interest**. • Student-related factors; affected by learning environment.
C	• …when they experience academic & personal **Caring**. • Instructor effectiveness & group dynamics.

Concluding Remarks

- PBL implementation may vary, but generally involves student-centered learning facilitated using ill-conditioned, real-world problems.
- Chemical Engineering lends itself well to PBL, linking open-ended problems to industrial applications.
  - Students' focus is on the problem-solving process, not just the "right" answer.
- Effective PBL requires consideration of both the learning environment & student-related factors.
- Significant overlap exists between PBL characteristics & motivational influences.

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Motivating Chemical Engineering Students through Problem-Based Learning

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What motivates chemical engineering students? The primary motivation often seems to be obtaining high marks, which can only be achieved by getting the “right” answer. However, in focusing on the final result, students often ignore (or undervalue) the rest of the solution process.

Problem-based learning (PBL) is an attractive alternative to traditional lecturing in Chemical Engineering, as it provides opportunities for instructors (and, subsequently, students) to link technical knowledge to industrial applications. Open-ended problems (which may or may not have a single correct answer) encourage students to take ownership of their work, and emphasize the problem-solving framework rather than a single numerical solution.

In order for PBL to be effective, facilitators must carefully evaluate the PBL learning environment and any student-related influences. Facilitator involvement, problem selection, and assessment technique are the most important environmental considerations. Similarly, the most relevant student-related considerations are students’ personal situations, interest in the subject matter, and perceived ability to succeed. Although these factors are harder to observe (much less measure or modify), they are directly linked to students’ motivation.

Jones has developed the **MUSIC** Model of Academic Motivation, which provides targets for improving student motivation [1]. Research shows that students are more likely to be intrinsically motivated when they feel **empowered**, coursework seems **useful**, and students understand their path towards **success**. The learning environment should also be structured to maximize student **interest** and emphasize academic and personal **caring**.

Many of these targets are directly aligned with the properties of PBL, which suggests that implementing PBL will improve student motivation. Students are empowered to make their own decisions throughout the solution process. They can immediately see the usefulness of PBL, especially since course content may be extremely interactive. When students have a good understanding of the problem (and appropriate opportunities for feedback along the way), they are able to visualize steps for success. Hopefully, the real-life relevance will improve student interest in the course content. Finally, regular check-ins with the course instructor will ensure that the students feel cared for; their instructor is available to help them succeed.

Increasing student motivation is only one of many benefits of PBL [2]. By increasing motivation, students may be more inclined to engage throughout the learning process, thus focusing on the entire solution process. Thus, chemical engineering instructors can use PBL to encourage their students to look beyond the “right” answer.

References

[1] Jones, B. D. (2009). Motivating students to engage in learning: The MUSIC model of academic motivation. *International Journal of Teaching and Learning in Higher Education, 21*(2), 272-285.

[2] Woods, D. R. (2012). PBL: An evaluation of the effectiveness of authentic problem-based learning (aPBL). *Chemical Engineering Education*, 46(2), 135-144.