ENHANCING ENGINEERING EDUCATION THROUGH INNOVATIVE LEARNING APPROACHES

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Abstract. This article explores two key perspectives on innovation in engineering education. First, innovation is viewed as an outcome-oriented process, where learning is demonstrated through the creation of artifacts at the conclusion of a project. Second, innovation is understood as a transformative process that reshapes how students learn and encourages educators to adopt new methods. Drawing on qualitative data from engineering design courses, this research highlights how learning elements impact students in the early stages of innovation. By actively applying these elements, early-phase innovation can strengthen current and future engineering curricula and programs. The study emphasizes authentic learning experiences where students engage directly with new knowledge and educators refine teaching practices. To succeed, students need clear guidance on when and how learning elements should be reinforced. Such integration enhances their ability to act, apply knowledge, and adapt in diverse learning situations. Ultimately, balancing educator strategies with student engagement is essential for fostering meaningful innovation in engineering education.

Keywords: Engineering education, innovation, design, learning elements, student, change

Annotatsiya. Ushbu maqolada muhandislik ta’limida innovatsiyalarga oid ikkita asosiy nuqtai nazar o‘rganiladi. Birinchidan, innovatsiya natijaga yo‘naltirilgan jarayon sifatida qaraladi, bunda o‘rganish loyiha yakunida artefaktlarni yaratish orqali namoyon bo‘ladi. Ikkinchidan, innovatsiya o‘quvchilarning bilim olish usullarini o‘zgartiradigan va o‘qituvchilarni yangi usullarni qo‘llashga undaydigan o‘zgaruvchan jarayon sifatida tushuniladi. Muhandislik loyihalash kurslarining sifatli ma’lumotlariga asoslanib, ushbu tadqiqot o‘quv elementlarining innovatsiyalarning dastlabki bosqichlarida talabalarga qanday ta’sir qilishini yoritib beradi. Ushbu elementlarni faol qo‘llash orqali erta bosqich innovatsiyasi joriy va kelajakdagi muhandislik o‘quv rejalari va dasturlarini kuchaytirishi mumkin. Tadqiqotda o‘quvchilar yangi bilimlar bilan bevosita shug‘ullanadigan va o‘qituvchilar o‘qitish amaliyotini takomillashtiradigan haqiqiy ta’lim tajribalariga alohida e’tibor qaratiladi. Muvaffaqiyatga erishish uchun o‘quvchilarga o‘quv elementlarini qachon va qanday mustahkamlash kerakligi haqida aniq ko‘rsatmalar kerak. Bunday integratsiya ularning xilma-xil o‘quv vaziyatlarida harakat qilish, bilimlarni qo‘llash va moslashish qobiliyatini oshiradi. Oxir-oqibat, muhandislik

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ta’limida mazmunli innovatsiyalarni rivojlantirish uchun o‘qituvchi strategiyalari va o‘quvchilarning faolligini muvozanatlashtirish muhim ahamiyatga ega.

Kalit so‘zlar: Muhandislik ta’limi, innovatsiya, dizayn, o‘quv elementlari, talaba, o‘zgarish

Аннотация. В данной статье рассматриваются два ключевых подхода к инновациям в инженерном образовании. Во-первых, инновации рассматриваются как процесс, ориентированный на результат, где обучение демонстрируется посредством создания артефактов по завершении проекта. Во-вторых, инновации понимаются как преобразующий процесс, который меняет способ обучения студентов и побуждает преподавателей применять новые методы. Опираясь на качественные данные курсов инженерного проектирования, данное исследование подчеркивает, как элементы обучения влияют на студентов на ранних этапах инновационного процесса. Активное применение этих элементов на начальной стадии инноваций может усилить текущие и будущие инженерные учебные планы и программы. В исследовании делается акцент на аутентичном учебном опыте, где студенты напрямую взаимодействуют с новыми знаниями, а преподаватели совершенствуют практику преподавания. Для достижения успеха студентам необходимы четкие указания о том, когда и как следует закреплять элементы обучения. Такая интеграция повышает их способность действовать, применять знания и адаптироваться к различным учебным ситуациям. В конечном итоге, баланс между стратегиями преподавателя и вовлеченностью студентов имеет решающее значение для развития значимых инноваций в инженерном образовании.

Ключевые слова: инженерное образование, инновации, проектирование, элементы обучения, студент, изменения

Introduction.

Future innovations demand engineers who can apply their knowledge and skills to create products and processes that previously did not exist. This research focuses on how engineering students learn through courses that allow them to test and develop design skills. The author has taken on dual roles as both lecturer and researcher, ensuring that student learning remains the primary focus while also exploring new teaching insights. In today’s rapidly changing world, accredited engineering programs are under continuous pressure to reform pedagogical approaches [1]. National and international organizations emphasize the need for engineers who are not only technically proficient but also innovative and adaptable. Engineering education thus serves as both an academic foundation and a response to technological and societal needs. The growing field of engineering education

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research has developed into a recognized discipline, contributing valuable insights into teaching practices and student learning [2]. Universities worldwide have implemented faculty development programs to improve teaching quality, while research publications have created greater transparency and knowledge sharing. Engineering education today emphasizes not just knowledge transfer, but also the integration of problem-solving, creativity, and innovation into the learning process. This study examines innovation from two perspectives: as an outcome expressed through tangible project results, and as a process that transforms student learning. It argues that early exposure to innovative practices strengthens students' abilities to generate new ideas, synthesize knowledge, and adapt to real-world challenges.

Literature review

The setting in which design involves 'newness' is considered crucial to early product and process innovations in engineering education [3]. However, the effectiveness of outcome-based education has been debated, and particularly whether output-derived project achievements best reflect a requested learning achievement by students. Research from the learning sciences shows that prior knowledge plays a critical role in how students progress through a problem, as well as in what they learn and what they produce . Learning in this thesis base curricular innovations he [4], both as a policy-making, institution-wide systematic concern, and its individual support for learning. In the support for individual learning teaching methods' has become focal point namely as change mechanisms behind efforts to promote student learning with learning experiences that lasts [5]. More distinctly teaching methods that concern change imperatives have been clustered in a set of areas that strive to support learning in different forms; e.g. self-directed student learning, collaborative learning and problem-based learning.

Innovation in education has, until recently, been omitted or regarded as a side track in course- or programme-design templates. The international initiative of the CDIO syllabus is set to change perspectives on innovative aspects, given that such factors are part of the extended version—the recently updated v2.0. The syllabus advocates for pioneers to test, implement or in other ways contribute with examples that enhance learning. Engineering education research has a tendency to transfer learning experiences through cases that allow descriptive evidence of the ways design challenges are apprehended [6].

Methodology. From an educational point of view, student learning has evolved from a tradition in which lecturers communicated in a unidirectional format, especially in intense, theory-based subjects [7]. Whether innovation in engineering education resides strictly in a more theoretical or a more practical approach or in a mixture of the two depends upon existing lecturing traditions,

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existing curricula, and existing programme outlines. This research pursues innovation as the process of establishing a valuable output that corresponds to or exceeds existing or latent user needs. The value build-up involves internal progression through student learning; the focus is on experiencing this emerging build-up, also cited as 'experiential learning'; 'pragmatic knowledge', and 'functional knowledge'[8].

Provided with an educational perspective engineers are perceived to integrate and synthesize new knowledge as something logically structured and possible to be acted upon. From this perspective, what has been addressed as early indications to product innovations is frequently situated in ideas that shape cognitive beliefs in communication and social interplay [9]. In parallel with idea-generating methods, prototyping defines lateral thinking as present wherever divergence and systematic thinking are unified [10]. The benefits of prototyping as part of early product innovation exploration have been researched very little, especially considering prototyping's design importance [11].

Past research has addressed students approach to learning as being related to different type of styles and preferences. By tradition information has been transferred through visual or verbal demonstrations and explanations with risk of making students passive recipients to new knowledge. Kolb has presented this in a scale of active and reflective sensory [12]. Bergsteiner, Avery and Neumann address an active learning approach as a step that concerns interaction, discussion and a basis for reflection on performed and not performed activities. Early stages of innovation are regarded as informal and ambiguous, which for the teaching and learning of innovation provides no exact positioning of specific content or principles to be applied. Rather the promotion of skills, approaches and methods of thinking has come to guide and embrace innovation as a learning phenomenon in engineering education. Individual abilities to achieve in-depth technical expertise and to communicate laterally—as the ingredients required to establish value and novelty [13].

Result and discussion. Design thinking provides a mindset that encapsulates the design of new products in creative and innovative ways. Design thinking could also be portrayed as a framework that is founded in human-centered actions and cognition, concerning how to understand (the user and the system); observe, point of view; ideate; prototype and test. Design thinking provides a wide array of interpretations, in order to relate to an engineer's perspective the definition by Dunn and Martin is used: "the way designers think: the mental processes they use to design objects, services or systems, as distinct from the end result of elegant and useful products. Design thinking results from the nature of design work: a project based work flow around 'wicked' problems." [14,15].

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Fig 1. Wicked' problems.

Planning, guiding, assessing, and facilitating students are aspects that provide a basis for change efforts in curriculum; innovations in regards to curricula redesign corresponds to new and creative implementations made by faculty in courses and programmes. Curricular innovations concern improvements that lecturers undergo as they evolve in their role—an internal self-regenerating innovation process. Barton, Schlemer, and Vanasupa expand the phenomenon of innovation in engineering education by differentiating it into three domains, each with its own practices and process.

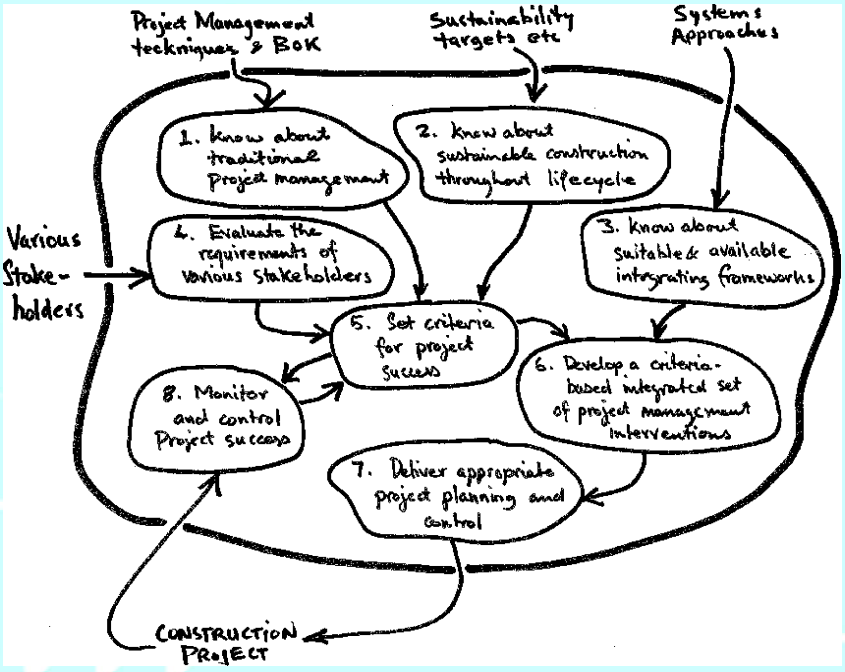


Fig 2. Making Sense of Wicked Projects

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Problem solving — The first domain captures innovation within the bounds of a process or set of processes. Problem solving looks at what is already being done, with perhaps additional efficiency, resources, speed, or scale. Problem solving usually results in incremental changes to existing designs.

Process improvement — The second domain views innovation as a phenomenon arising from examining the process of problem solving. Process improvement has the potential for designs of greater impact, since the boundaries of consideration now include incremental and systemic improvements.

Transformation — The third domain regards innovation as a transformation that inspires a fundamental identity shift in the surrounding system and the people. This domain addresses deep structures and patterns of thought, habit, and behaviour. Transformational innovation is also considered a context for profound change in the other two domains and as such is an emergent influencer.

Conclusion.

The context that handles emerging problems is also the basis for refining and improving the problem-solving skills applied. The third domain concerns a greater systematic shift whereby transformational innovation or curricula innovation (Haggis, 2009; Sheppard, et al, 2006). A foundational tenet of this thesis is that innovation in engineering education is diverse in nature; one should approach it as such in order to understand its complexity. Overall, the literature demonstrates that integrating innovative teaching practices into engineering curricula is crucial for preparing students to meet the demands of a rapidly evolving technological and industrial landscape.

REFERENCES:

1. Adams, J., Kaczmarczyk, S., Picton, P., & Demian, P. (2010). Problem solving and creativity in engineering: conclusions of a three-year project involving reusable learning objects and robots. Engineering education, 5(2), 4-17.
2. Amidon, D. (2003). The Innovation Highway. Boston: Butterworth-Heinemann.
3. Bernhard, J., (2010). Insightful learning in the laboratory: Some experiences from ten years of designing and using conceptual labs, European Journal of Engineering Education, 35(3), 271-287.
4. Beskow, C., & Ritzén, S. (2001). Performing Changes in Product Development – an Implementation Framework with Keys. The Journal of Research in Engineering Design, 12(3), 172-190.
5. Biggs, J. (1999). Teaching for Quality Learning at University. Buckingham: SRHE/OUP.
6. Biggs, J. B., & Collis, K. F. (1982). Evaluating the Quality of Learning-the SOLO Taxonomy, 1st ed., New York: Academic Press.
7. Bryman, A. (2008). Social Research Methods (3rd edition). Oxford, UK: Oxford

ISSN 3030-3907

University Press.
8. Bryman, A. & Bell, E. (2005). Företagsekonomiska Forskningsmetoder. Håkansson, O (ed.) Malmö: Liber AB Burton, R., Schlemer, L. & Vanasupa, L. (2012). Transformational Innovation: Reflections on How to Foster it in Engineering Education Systems. International Journal of Engineering Education, 28(2), 275–285.
9. Byrd, J. & Brown, P. L. (2003). The Innovation Equation, Building Creativity and Risk Taking in Your Organization. San Francisco, CA: Wiley.
10. Carrillo, A., Carrizosa, K., & Leifer, L. (2003). Design team coaches. In Proceedings of the 2003 American Society for Engineering Education annual conference and exposition.
11. Carleton, T. and Cockayne, W. (2009). The power of prototypes in foresight engineering. In Proceedings from the 17th International Conference of Engineering Design, ICED'09, Stanford, CA.
12. Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: opportunities and challenges. Academy of management journal, 50(1), 25-32.
13. Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. Journal of Engineering Education, 78(7), 674-681.
14. Felder, R. M., Woods, D. R., Stice, J. E., & Rugarcia, A. (2000). The future of engineering education II. Teaching methods that work. Chemical Engineering Education, 34(1), 26-39.
15. Gibbs, G. (1992). Improving the Quality of Student Learning. Bristol: TES.

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