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Fostering Innovation and Understanding in Fluid Mechanics through Real-World Projects

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Abstract. Innovation is a critical skill that engineering students need to build during their university education. Despite its recognized importance, innovation has not been incorporated enough into engineering courses. One of the fundamental courses in the mechanical engineering curriculum is Fluid Mechanics, which can be taught in a way that includes innovation projects to enhance the students' conceptual understanding and creativity. This paper presents a framework of a structured approach to achieve this goal. For each chapter, a real-world problem is solved during the tutorial sessions through active learning. Each team simulates their proposed solution using SolidWorks flow simulation software. An assessment rubric is used to evaluate the students' solutions. Short courses on the innovation life cycle and SolidWorks Flow Simulation are included to enhance the effectiveness of the approach. In addition to boosting the students' innovation skills, the approach is expected to enhance their ability to deal with real-world problems they will face in their working lives. A key challenge of this approach is the nature of the fluid mechanics course since it is a basic course that focuses on the principles more than design. Nevertheless, the approach is usable with the course to a certain limit.
Keywords: innovation; fluid mechanics; simulation

1. Introduction

The renewing world's problems require innovative solutions, and even traditional problems may need more efficient ones. That shows why innovation is a critical skill for engineering students who will deal directly with the world's problems after their graduation.

Innovation is a skill that is built by continuous, gradual practice, which might be done consciously through the engineering curriculum. So all engineering courses, from the fundamentals to the design and applied courses, can be taught in a way that enhances, to a certain limit, the students' ability to innovate.

Fluid mechanics is an essential course in the undergraduate mechanical engineering curriculum. It is a fundamental course that studies the statics and dynamics of fluids, in addition to their properties. Students usually study this course in the fifth semester.

Baričević and Luić [1] explored the ability of enhancing the students' innovative thinking by learning the design thinking process as an active learning technique in a Business Economics course. The students in the study showed enhancement in the critical assessment and innovation process recognition. Cioc et al. [2] applied online project-based learning in the Fluid Mechanics course to apply the

information literacy skills in designing HVAC duct systems. The results showed an enhancement in the students' knowledge of the topic of internal airflow. Pérez-Sánchez and López-Jiménez [3] applied Continuous Project-Based Learning in the fluid mechanics courses at the bachelor's and master's degrees to enhance the understanding and satisfaction. Mora-Melia et al. [4] integrate Problem-based learning (PBL) with computational fluid dynamics (CFD) in Fluid mechanics teaching for civil engineering. This teaching method improved the students' performance and motivation. Sekaran and Rodak [5] enhanced the learning experience for multidisciplinary teams in the Fluid Mechanics course using physical model projects. Using short CFD simulation activities, Rodríguez-Martín et al. [6] improved learning and motivation of the students of Fluid Mechanics. The teams' differences were respected in the activities' selection. Engineering education is centered on problem-solving and design, which are key student outcomes in the ABET criteria and are closely related to innovation [7].

This paper presents a framework for a suggested approach to teaching fluid mechanics with the aim of raising the students' innovation skills and enhancing their understanding of the concepts by solving real-world problems related to fluid mechanics.

2. The Proposed Framework

The proposed framework relies on an active learning technique, involving teams that are asked to solve a real-world problem during the tutorial sessions. Each team will simulate their proposed solution using SolidWorks Flow Simulation software. Real problems related to all chapters will be assigned at the beginning of the semester. Table 1 shows suggested projects for solving real problems related to the course topic.

Table 1 suggested projects for solving real problems related to the course topic

Topics	Suggested projects
Viscosity	The syrup dispenser for viscous liquids, such as honey, drips after being released. Design a dispenser nozzle to prevent the liquid from dripping.
Hydrostatic forces	Control the irrigation canals' gates without electronics.
Buoyancy	In the desert where no electricity, get the benefit of the water tanks for food and drinks cooling by designing a food and drink container that can submerge in the water to a preselected depth.
Liner momentum	Reduce the reaction force of firefighting nozzle that felt by the fire fighter

To solve the problem, each team should follow the strategy of creative problem solving [8]. The strategy includes five steps. The first step is redefining the problem accurately to clarify what causes the problem. The second step is brainstorming to generate solutions. The third step is deciding the criteria for the suitable solution selection, in addition to applying the criteria and selecting the most suitable solution. The fourth step is implementing the chosen solution, while the fifth step is evaluating the solution after its implementation. In the proposed approach, the implementation will be done by SolidWorks, and the evaluations will be achieved by SolidWorks flow simulation. Table 2 presents the rubric for evaluating the projects. The submitted work will be evaluated according to three items: problem definition, problem solution, and simulation quality. For each item, the student might get 3, 2, 1, or 0 scores after evaluating his work depending on the rubric. In addition, the students will be informed clearly that they must achieve academic integrity. Meanwhile, The students data should be treated according to the university bylaws.

Table 2 the rubric for evaluating the projects

Item evaluated	**3**	**2**	**1**	**0**
Problem definition	The problem was defined by determining the root reasons, in addition to defining the problem constraints.	The problem was defined by determining the root reasons, without defining the problem constraints.	The problem was described without determining the root reasons nor the problem constraints.	The problrm definition is missing.
Problem solution	The problem was totally solved by a novel and creative solution while respecting the constraints.	The problem was partially solved by a novel and creative solution while respecting the constraints.	The problem was totally solved by an existing solution.	The problem was not solved
Simulation quality	The solution was simulated with a proper mesh and acceptable convergence criteria.	The solution was simulated with a proper mesh and insufficient convergence criteria.	The solution was simulated with a poor mesh and insufficient convergence criteria.	The simulation was not performed

To enhance the students' awareness about innovation, a short course about the innovation life cycle will be provided. The course will cover the stages from the idea generation and validation until selling the product. The index of Technology Readiness Levels (TRL) will be explained.

To evaluate the proposed solution, the students will simulate it using the SolidWorks flow simulation software. A short course about the software will be provided for the students to make them familiar with it. The course will identify how to define the boundary conditions and how to decide the suitable specifications for the mesh. The solution convergence criteria will be explained. Deciding a suitable way of presenting the results according to the simulation goal will be discussed.

3. Expected Outcomes

This approach is expected to encourage the students to use the scientific principles learnt in solving the problems that they will encounter and therefore enhance their innovation skills. In addition, it is expected to improve the students' insight into the concepts of the course, whereas applying the concept in solving a problem is a branch of the concept's understanding. The approach will enhance the

students' ability to deal with open-ended problems since the students usually work with closed-ended problems in the homework, quizzes, and exams. The students' scientific level is a limitation of the approach. The students typically study the Fluid Mechanics course while they are Sophomores, so it's challenging for them to address multidisciplinary problems. Therefore, the instructor needs to consider this issue whenever selecting problems.

4. Conclusion

This paper discussed a proposed approach to teaching Fluid Mechanics to enhance the students' understanding and innovation skills by solving real-world problems related to the course topics. After applying the approach, the results on the students' performance are appropriate for future publication. The real-world problems have potential to be present in all engineering courses.

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Conflicts of Interest: The authors declare no conflicts of interest

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