

## Evaluation on Students' Achievement for Outcome Based Education on Engineering Students

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### ABSTRACT

This article explores the implementation and impact of Outcome-Based Education (OBE) in engineering programs, emphasizing the shift from traditional methods to focusing on students' higher-order thinking and practical skills. It highlights how various educational standards, such as those from Engineers Australia and ABET, align with OBE principles. Using an anonymous online survey, the study evaluates the Program Educational Objectives (PEOs) achievement among graduates from the Mechanical Engineering Education Department at Universitas Negeri Medan. The survey covers graduates' skills in areas like mathematical tools, 3D modeling, and engineering project execution. Results indicate that while some PEOs are satisfactorily achieved, others, such as PEO3 (3D modeling skills) and PEO7 (experimental approaches), require improvement. The study suggests enhancing curriculum components to better align with industry needs and continuously improve educational quality. Future research should incorporate employer feedback to provide a more comprehensive evaluation of graduates' preparedness.

**Keyword :** Outcome-Based Education (OBE), evaluation, engineering graduates

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### 1. INTRODUCTION

incorporates Outcome-based Education (OBE). For instance, the Australian Graduate Attributes established by Engineers Australia (2005) and the basic criteria established by the Accreditation Board for Engineering and Technology (ABET) (ABET 2012) in the US both pertain to the evaluation and assessment of students' learning outcomes (2005).

SEAMEO (Southeast Asian Ministers of Education Organization) of Indonesia sets the standards for accrediting Indonesia universities; according to Aziz et al. (2005), the SEAMEO is also working towards OBE implementation. The fundamental reason for this widespread acceptance is that OBE promotes a change in emphasis from conventional methods of accumulating course credits to the development of students' capacity for higher-order thinking and the completion of challenging assignments. The hope is that this will provide a more accurate picture of how well the pupils have learned the fundamentals. According to Malan (2000), when an institution decides to apply OBE, it will have to reorganize its educational program, classes, curriculum, evaluation, and reporting systems.

The taxonomies developed by Bloom (1956) and others for educational aims gained significant traction in the 1950s. The taxonomies served as benchmarks for setting precise goals and creating criteria to measure whether or not learners met those goals in relation to the intended learning outcomes. When it comes to evaluating OBE, Bloom's work is still crucial, especially when it comes to the cognitive domain. Assessments should be tied to either the major and long-term results that learners are expected to achieve or to the short-term enabling outcomes that are generated from these long-term achievements (Killen, 2000). 'Clarity of focus' and 'designing back' are the guiding ideas here.

According to Killen's definition of OBE, there are two main kinds of outcomes (2000). The first one is more concrete and focuses on things like grades, test scores, percentages of students who finish a course, and their ability to find work after graduation; the second one is less concrete but often asks students to describe what they've learned and how well they can apply it. It prioritizes the learner's future professional achievement by focusing on long-term results. Focus, opportunity, high expectations, and design down are the four pillars upon which OBE rests (Brandt 1992).

Keeping the intended learning goals of the students in mind while designing the curriculum is essential for maintaining attention. These should not be weekly, monthly, or annual goals, but rather long-term outcomes that students aim to attain by the time they graduate and beyond. This further highlights the need of seeking out opportunities for ongoing professional growth. The second tenet, "expanded opportunity," is to allow students more options for reaching the desired results. Within the OBE framework, methods such as classroom instruction, student-led projects, quizzes, workshops, departmental briefings, industrial attachment, departmental visits, student-led sharing sessions, and competitions are utilized.

All students are expected to maintain a high level of performance in accordance with the high expectations philosophy. The ability to think critically and structurally is an essential skill for students to acquire. To keep track of consecutive thoughts, they need to make good use of engineering concepts and common sense. We also strongly value the following attributes: the ability to learn quickly by organizing knowledge rather than merely receiving it, the ability to handle engineering challenges holistically while maintaining necessary safety measures, and an understanding of sustainability and engineering.

Finally, according to the design-down concept, all pedagogical practices and curriculum development must be in line with the results achieved at each level. Exit, Program, Course, Unit, and Lesson Outcomes are the hierarchical steps that Spady (1994) uses to show how outcomes evolve. Figure 1 shows how the long-term Programme Educational Objective (PEO) must be monitored for a minimum of five years after graduation as part of the overall accomplishment assessment, which is linked to the learner's long-term educational outcomes.

## 2. METHOD

An anonymous online poll is the primary tool for determining the degree of PEO achievement. The target group for this study consists of bachelor from the Mechanical Engineering Education Department of Universitas Negeri Medan. A total of fifty-one respondents were chosen for the study. We then use the survey data to examine the PEOs' degree of achievement. Personalised survey questions need to be developed for each class. A focus group discussion with departmental staff members helped refine the set of questions used to create the survey. A five-point scale ranging from "extremely satisfied" to "very dissatisfied" was used to quantify the degree to which PEOs had been achieved in an anonymous online poll based on the results of the focus group.

Table 1. PEO's of Unimed Mechanical Engineering Education

PEO	Statement
PEO1	An understanding with the mathematical and computational tools utilised in mechanical engineering, as well as the science behind the field's guiding principles and methods,
PEO2	Understanding of these concepts and their practical application in mechanical engineering
PEO3	Competence in three-dimensional modelling, design, and analysis of parts and assemblies
PEO4	The ability to design and develop engineering components and equipment with a solid understanding of material qualities, production procedures, and how to use them cost effectively
PEO5	Capability to articulate thoughts clearly in a variety of contexts, including but not limited to written reports, oral presentations, and group work
PEO6	The capacity to develop and execute engineering projects while demonstrating initiative and entrepreneurship when working as a team
PEO7	Practice becomes perfect when it comes to using experimental approaches

PEO8	The understanding of the social, managerial, and financial contexts in which PME's operate, as well as their duties within those contexts
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A total of 34 questions covering topics such as specifics, professional development, compensation scale, career prospects, continuous professional training, and PEOs make up the online questionnaire survey.

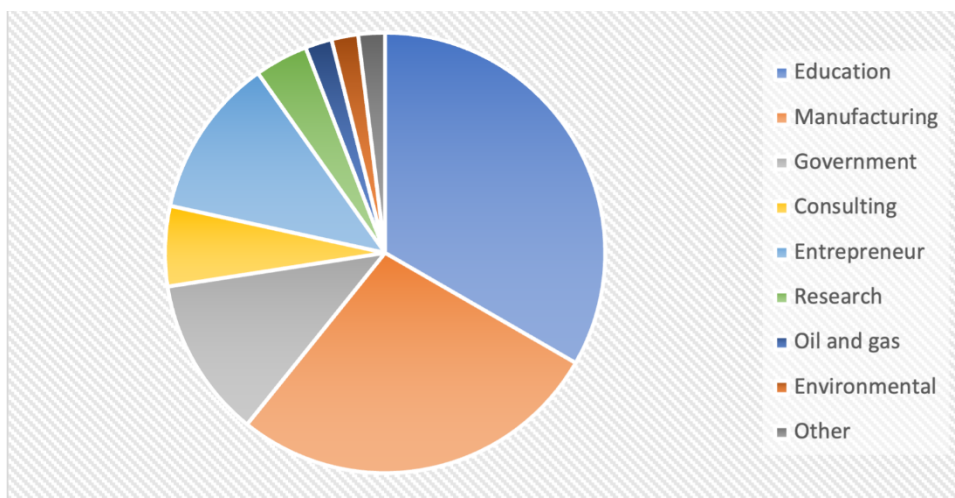
Table 2. Department-established learning objectives that focus on transferrable skills

	Skills
S1	Competence in writing technical reports
S2	Confidence in delivering complex presentations
S3	Competence in conveying ideas clearly
S4	Capacity to lead and work well with others
S5	Able to utilise a variety of IT resources
S6	Learn to solve difficulties using a scientific method
S7	Capacity to study on one's own and adopt a critical mindset when conducting research

Respondents might have been any alumnus who had graduated within the past three years. In order to track the student's professional development after graduation, we created this questionnaire survey. The survey is designed to be concise, easy to understand, and plain in order to attract a higher percentage of participants. At the beginning of the session, the alumni are given access to the survey, which serves an obvious purpose while simultaneously stressing the poll's anonymity. The survey is made available to alumni who agreed to participate via a web link and has a predetermined duration. If they do not feel comfortable submitting their survey, they are offered the option to withdraw at any time. The collected data is subjected to statistical analysis once the results are obtained. The percentage of a specific finding is determined by analysing quantitative data and visualising it in graphs and charts. Different parts of the PEOs are graded as "high" (above 70%), "medium" (50-69%) or "low" (49% and below) based on the percentage. with the purpose of determining what aspects of the PEOs are most important for the engineering program's educational system to undergo ongoing quality improvement. *System Model*

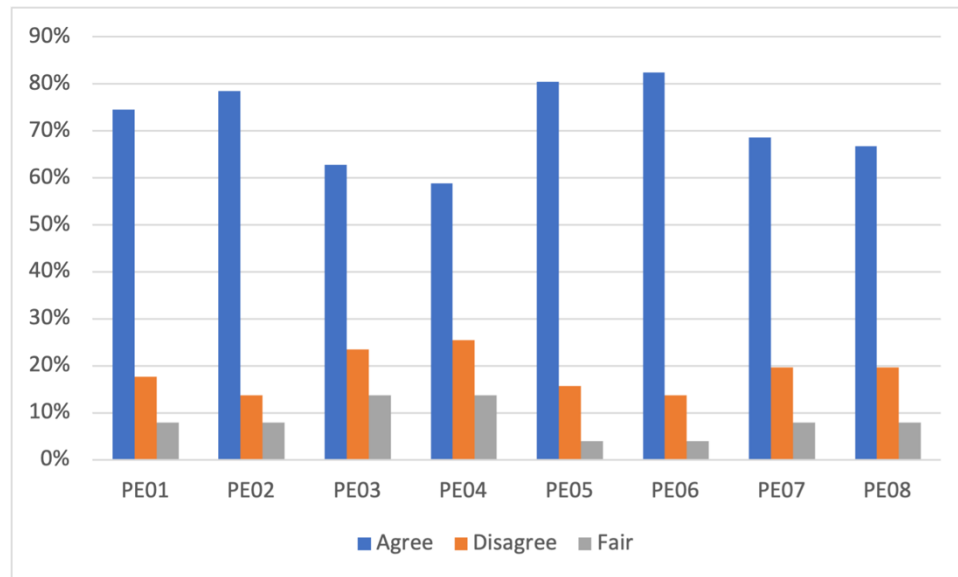
**3. RESULTS AND DISCUSSION**

The graduates who took part in the survey are working in diverse clusters of industries, as shown in Figure 2. Half of all responders fall into one of three categories: manufacturing, consulting, or the education field.



**Fig 2. Respondents' career-related industrial clusters**

Figure 3 displays the results of the survey questionnaire regarding alumni PEO attainment. Figure 3 shows that out of the total number of PEOs, four (PEO1, PEO2, PEO5, and PEO6) have attained a satisfactory level of attainment (>70%), while the other PEOs have failed to do so. This CQI procedure would take into account the PEOs with a percentage below 70%, which are PEO3, PEO4, PEO7, and PEO 8



**Fig 3. Statistics from a questionnaire survey**

Achievement rates above 70% were reached by PEO1, PEO2, PEO5, and PEO6. These PEOs are associated with mechanical engineering education's foundational principles and their practical applications, strong oral and written communication skills, and the capacity to work collaboratively on engineering projects while demonstrating initiative and enterprise. Because these PEOs form the backbone of the mechanical engineering curriculum, students are required to study them extensively throughout the degree, particularly in the required courses like solid mechanics, thermodynamics, materials and manufacturing, structural vibration, and professional studies. As a result, numerous courses required students to work in teams, such as Design and Manufacture, Group Design Project, and Group Design and Make. In order to gain the necessary experience in implementing their knowledge in a practical setting, students are obliged to complete a 12-week industrial internship. To further foster a culture of teamwork and provide students with experience in using these ideas in their career after graduation, it is highly urged that they engage in team contests like the Bosch Power Drill Race, Formula Varsity, the James Dyson Award, etc. The graduates' faith in their ability to achieve these PEOs has been bolstered by this.

With 60%, PEO3 has the poor achievement rate. All eyes are on the grads' three-dimensional visualisation, design, and analysis skills. The delivery, contents, and assessment of modules containing design aspects are crucial to the achievement of this PEO. The students' lackluster performance suggests that they could benefit from additional instruction in creating orthographic and auxiliary projections, isometric views, sectioning, dimensioning, and assembly drawings for their 3D engineering models. This would also help them improve their perceptions in conceptual, embodiment, and detailed design. A variety of CQI techniques were to be used throughout the program, including strategies to enhance the accomplishment of PEO3. Some of these changes include adding a detailed how-to guide to Moodle (the university's virtual learning environment), hiring more research assistants with 3D modeling expertise, bringing in industrial lecturers to help teach design, making sure the video demonstrations used are up-to-date and well-executed, and making the program's assessment process more efficient.

Graduates' knowledge of materials, production, and cost-effective design and system development are the primary foci of PEO4. Both the "design" and the "practice" components of the UK-SPEC Learning

Outcomes are relevant here. Graduates' perceptions of their own acquisition and application of this educational purpose were low, with only 59% expressing this sentiment. The graduates' low achievement rate suggests that the program design might benefit from more hands-on experience with costing and more opportunities to think creatively and innovatively about how to enhance engineering systems. There are a number of factors, including the graduates' job responsibilities and the type of the company they work for, that could explain why they never get the chance to put the expertise to use in the real world. To increase the attainment of this PEO, it is recommended that the design, materials, and manufacturing modules have more practical features. As an example, students may be required to incorporate a marketing strategy, cost estimates, and a business plan into their design project. It is also important to prioritize material design optimization, which aims to strike a balance between system performance and cost-effective materials.

It is clear from the graduates' poor PEO7 accomplishment that they lack the self-assurance to regularly apply and successfully employ systematic experimental approaches in engineering problem-solving procedures. Students may lack faith in experimental methods if they are worried about the potential dangers to their health and safety during the procedure, if they are unable to solve problems they have never encountered before, if they cannot use mathematical or computer-based models to come up with workable solutions, if they cannot determine the limits of a given case, and if they cannot set up and execute suitable experiments to test their proposed solutions. The need to equip pupils with a repertoire of experimental approaches and an understanding of the risks involved is imposed by the task of raising the achievement level in PEO7. Because of this, the supply of modules will have to be rethought to incorporate laboratory experiments and a machining workshop. The related hazards need to be modified to fit a specific laboratory or workshop in addition to a standard set of health and safety requirements. Experimental approaches, in addition to the foundational engineering knowledge, usually demand for a hands-on approach, where students' senses of sight, sound, and touch work together to deliver valuable exercises that enhance their confidence. This is why it's important to improve laboratory activities that involve small groups so that every student can participate in practical experiments. Due to the overemphasis on measured data and students' subsequent engineering computations, the evaluation of students' understanding of experimental process is sometimes lacking in rigorous testing. Instructors should pay more attention to making sure that the best practises are followed and the laboratory assessment sheet should take into account the different levels of Bloom's taxonomy to improve this part.

PEO8 is based on the assumption that graduates will understand their social, managerial, and financial obligations within the context of their profession as Professional Mechanical Engineers. According to the findings, very few graduates feel that their degree adequately prepared them for the demands of their profession. Additionally, there is a noticeable lack of focus on management, business, and financial concepts necessary for engineers to effectively carry out their duties. A suggestion has been made to improve performance in PEO8 by incorporating aspects of engineering practice into some of the classical modules. It is desirable to incorporate these aspects into core courses rather than teach them separately because students are finding it difficult to connect professional practices to technical knowledge.

#### **4. CONCLUSION**

This article details a survey that was conducted to assess the degree holders' achievement level of course-related PEOs within five years after graduating from the Unimed Mechanical Engineering Education program. The PEOs used in the survey were pre-determined and aligned with the UK-SPECS objectives. Graduates rated their own performance on most PEOs as above satisfactory, according to the poll. In addition, the results demonstrated that four areas (PEO3, PEO4, PEO7, and PEO8) had comparatively poorer attainment according to the graduates' ratings. These findings shed light on the reasons of unsatisfactory accomplishment and how the graduates themselves assessed their own attainment. Following the UK-SPECS and BEM standards, suitable suggestions were made. Modifications are planned to be made in the upcoming school year to raise the degree of achievement of these PEOs, and this procedure is a component of the department's CQI process strategy.

The study's findings are based solely on the responses of graduates to a survey about their experience in completing the degree program; it doesn't take into account any confounding variables that may exist after graduation. Assessing the exposures and experiences of graduates as individuals and plans for professional growth beyond graduation are two of the many topics that need to be addressed

in future works based on this study. To make the study more comprehensive, it would be beneficial to include feedbacks from employers as well.

## REFERENCES

- Anuar, A., Shuaib, N., Sahari, K. and Abidin, I. (2009) Continual improvement and assessment plan for mechanical engineering programme at UNITEN, pp19–24. Kuala Lumpur: IEEE.
- Aziz, A., Megat Mohd Noor, M., Abang Ali, A. and Jaafar, M. (2005) A Malaysian outcome-based engineering education model. *International Journal of Engineering and Technology* 2 (1), 14–21.
- Bloom, B.S. (1956) *Taxonomy of educational objective: handbook 1. Cognitive domain*. New York: McKay.
- Brandt, R. (1992) On outcome-based education: a conversation with Bill Spady. *Educational Leadership* 50 (4), 66–70.
- Engineering Council, UK (2010) *The accreditation of higher education programmes: UK standard for professional engineering competence*. London: Engineering Council, UK.
- Engineers Australia 2005. *Accreditation management system educational programs at the level of professional engineer*. Barton, ACT: Engineers Australia.
- Ho, J.-H., Tshai, K.Y. and Yap, E.H. (2013) Students' Attainment of Programme Objectives (POs) for the Mechanical Engineering Undergraduate Degrees at the University of Nottingham Malaysia Campus (UNMC), *International Symposium on Education, Psychology and Social Sciences (ISEPSS 2013)*. Kuala Lumpur, Malaysia.
- Killen, R. (2000) Standards-referenced assessment: linking outcomes, assessment and reporting. Keynote address at the Annual Conference of the Association for the Study of Evaluation in Education in Southern Africa, Port Elizabeth, South Africa, 26–29 September.
- Magee, C.L. (2004) Needs and possibilities for engineering education: one industrial/ academic perspective. *International Journal of Engineering Education* 20 (3), 341–352.
- Malan, S.P. (2000) The "New Paradigm" of outcome based education in perspective. *Journal of Family, Ecology and Consumer Sciences* 28, 22–28.
- May, E. and Strong, D. (2006) Is engineering education delivering what industry requires. *The Third CDEN Design Conference*, Toronto, Ontario, Canada.
- Owlia, M. and Aspinwall, E. (1996) A framework for the dimension of quality in higher education. *Quality Assurance in Education* 4 (2), 12–20.
- Owlia, M. and Aspinwall, E. (1998) A framework for measuring quality in engineering education. *Total Quality Management* 9 (6), 501–518.
- Rozeha, A.R., Mazlina, E., Sadruddin, M. and Abdullah, R. (2007) Continuous improvement in engineering education through effective value for money audits. In *Proceeding, Second International Conference on Engineering Education & Training (ICEET-2)*, MOVENPICK Hotel Kuwait, Kuwait City, Kuwait.
- Sani, M. et al. (2008) Assessment of the mechanical engineering programs by exit surveys at University Malaysia Pahang, pp317–323. Shah Alam, s.n.
- Shekar, C.R., Farook, O. and Bouktache, E. (2008) Continuous improvement process based on outcome based education. Nashville, TN: IAJC-IJME.
- Spady, W. (1994) Choosing outcomes of significance. *Educational Leadership* 51 (6), 18–22.
- Todd, R.H. and Magleby, S.P. (2005) Elements of a successful capstone course considering the needs of stakeholders. *European Journal of Engineering Education* 30 (2), 203–214.
- Waks, S. and Frank, M. (2002) Engineering curriculum versus industry needs: a case study. *IEEE Transactions on Education* 43 (3), 349–352.