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IMPLEMENTATION OF COMPLEX ENGINEERING PROBLEMS (CEP) AND COMPLEX ENGINEERING ACTIVITIES (CEA) OF UNDERGRADUATE PROGRAMMES IN MALAYSIA

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Abstract:

For decades, complex problem-solving skill has been identified as one of the key components required from fresh graduates to succeed in the workforce market. Specific for engineering undergraduate programmes in Malaysia, the Engineering Accreditation Council (EAC) Standard 2020 has prescribed the complex engineering problem (CEP) solving skills and complex engineering activities (CEA) as a part of its graduate attributes. However, in many cases, engineering programmes lack of a clear understanding of the requirements of complex engineering problems, hindering the students' mastery of engineering related problem-solving skills to face real-world problems' complexity. In this paper, an evaluation on the awareness and implementation of complex problem solving (CEP) skills and complex engineering activities (CEA) in the undergraduate engineering programmes in Malaysia is presented. Survey questionnaires were designed to gather feedback from academicians across various higher learning institutions (HLIs) that offer engineering programmes. This study which involves 120 experienced engineering lecturers from 23 public and private HLIs shows that project-based courses is the common courses chosen to address CEP and CEA including final year project, integrated design project, and design-related courses. The assessments of CEP and CEA are mostly conducted on a semester basis, utilizing project-based assessment. Problem-based learning (PBL) is the most widely chosen as teaching and

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learning strategy, engaging students in solving real-world problems, encouraging active participation, critical thinking, and the application of knowledge. In summary, this study contributes to understanding how CEP and CEA are implemented in undergraduate engineering programmes, and thereby represents a general framework to aid with the implementation of CEP and CEA in engineering education. Further research could explore the effectiveness and impact of these teaching and learning strategies on students' learning outcomes, students' abilities to apply CEP and CEA principles in real-world scenarios.

Keywords:

Complex Engineering Problem (CEP), Complex Engineering Activities (CEA), Teaching And Learning Strategies, Assessment Tools

Introduction

Real world problems are often multifaceted, complex, and lack of clear solutions path, hence the ever-increasing demand for enhancing competencies of professional engineers. Preparing engineering students for such environments through teaching complex engineering problems allow them to develop 'complex' skillsets that are beyond technical knowledge and propel them to succeed in their future careers. The concept of complex skillsets include problem solving, critical thinking, creativity in design thinking, and communication proficiency.

There is abundant literature on the importance and benefits of teaching complex engineering problems in engineering education. Incorporation of complex or ill-structured problems in engineering education provide an avenue for the undergraduate students to develop the complex skillsets to undertake complex engineering problem that they will encounter in their professional careers (Akinci-Seylan et al., 2022 and Pereira Pesso (2023)).

Batres (2022), Castaneda (2019), Kothiyal et al., (2015), and Hoffman (2014) among others have explored different research angles on the teaching and learning of complex engineering problems solving skills in engineering education. Batres (2022) showed that using a case study approach based on the concept of viewing the problem through real-world view (known as the Weltanschauung concept) for solving complex engineering problems led to an increased engagement level, ignited student curiosity, and enabled them to acquire new skills or knowledge, expanding their creativity and innovation. Castaneda (2019) focused on exploring students' awareness and stimulate their critical thinking skills on cultural, environmental, social, and political aspects in response to an ill-structured problem. The aim is to foster deeper understanding in dealing with complexities present in the engineering profession. Kothiyal et al. (2015) successfully demonstrated that teaching complex engineering problems through a 'delayed guidance' strategy encouraged students to adopt diverse problem-solving behaviours (i.e., exploratory, collaborative, adaptive, metacognitive, and creative behaviours) thereby improved students' complex skillsets. These studies demonstrated that incorporation of complex engineering problems in engineering education contributes to a more holistic development of engineering students' problem-solving competencies. The need for complexity skillsets in engineering students is not limited to only engineering technical knowledge but include engineering economics, business reengineering, and product design (Batres, 2022), and engineering ethics (Hoffman, 2014).

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Realizing the importance of immersing real-world complex problems in engineering education, both international and national engineering professional bodies have taken the initiative to include this element as one of the attributes required in engineering graduates. However, in many cases, engineering programmes lack a clear understanding of the requirements of complex engineering problems, hindering the students' mastery of engineering related problem-solving skills to face real-world problems' complexity. Therefore, investigation on the teaching and learning of complex problem solving (CEP) skills and complex engineering activities (CEA) is conducted to gain in-depth insights into the way it is put into practice by Malaysian engineering programmes. Prior to this case study, a pilot study was conducted and the findings were reported in Azmin et al. (2024). In this paper, the continuation of the pilot study on the evaluation of the awareness and implementation of complex problem solving (CEP) skills and complex engineering activities (CEA) in Malaysian undergraduate engineering programmes is presented.

Literature Review

Engineering Accreditation Council (EAC)

The complex engineering problem solving skill was emphasized in the graduate attributes required by International Engineering Alliance's (IEA) (2013) and in the programme outcomes required Engineering Accreditation Council, Malaysia's (EAC) (2020) accreditation standard. EAC requires that engineering degree programmes which seek accreditation must prepare graduates for future technological and societal changes, and able to acquire new knowledge through new problems (EAC, 2020). This skill was identified as the top skill needed to thrive in the 4th Industrial Revolution by the World Economic Forum (2016) and Ministry of Higher Education, Malaysia (Tapsir & Puteh, 2018) and it embodied the top two in-demand workers' core skills - analytical thinking and creative thinking skills - ranked by the World Economic Forum in its Future of Jobs 2023 report. Due to its importance, IEA released the attributes of complex engineering problems to guide the signatory countries of the Washington Accord in their implementation of incorporating complex skillsets in engineering curriculum starting in year 2013. These attributes can be used by the Higher Learning Institutions (HLIs) to mirror the problems in the classrooms with those in the industry. For all engineering undergraduate programmes under the purview of EAC, the implementation of CEP and CEA can be observed in the recent years to presently.

Implementation of CEP and CEA in Engineering Programmes in Malaysia

Realizing the importance of the implementation of CEP and CEA in the curriculums, engineering undergraduate programmes of the HLIs in Malaysia are continuously designed with effective incorporation of CEP and CEA to meet the requirements set by the EAC, in addition to to ensure that students are well-prepared and equipped with the necessary skills and knowledge for a successful professional career ahead. Some of the approaches taken to address CEP include problem-based learning and case studies (Nor & Zubir, 2023) and projects (Pasya et al., 2015) while CEA were integrated into courses such as Final Year Project, Industrial Training, Integrated Design Project, laboratory courses, and assignments (Mat Isa et al., 2021).

Mat Isa et al. (2021) conducted a survey involving 265 engineering educators, and the results indicated that most engineering programmes in Malaysia prioritize the incorporation of CEP within assignments or projects rather than in final examinations or mid-term tests. CEP is also integrated into a SULAM (Service-Learning Malaysia-University for Society) course, which

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engages students in service and collaborative learning to address complex issues and challenges identified in the society (Mat Isa et al., 2022). Although there are lack of evidences of the implementation of CEP and CEA in final examination and test in the HLIs in Malaysia, the finding from previous study showed that the practice does exist in some of the engineering programmes outside Malaysia, for example in the Static Field Theory course at Helsinki University of Technology, Espoo, Finland (Leppävirta et al., 2011).

Designing assessment incorporating CEP and CEA possesses certain challenges among educators to meet a balance between evaluating students' ability to tackle intricate engineering problems and the assessment tool that truly reflects their cognitive skills and understanding. Phang et al. concluded that there is a need for training programmes to equip lecturers with the skills to develop assessments that incorporate complex problem-solving. Their study highlighted that a group of engineering lecturers possessed only a fundamental grasp of complex engineering problems and addressed a restricted range of complex attributes (Phang et al., 2018). Liew et al. (2019) also found that the engineering educators often struggle to construct complex problems for their courses due to their limited understanding of the complex problems attributes.

Teaching and Learning Strategies to Improve the CEP and CEA

Numerous teaching and learning strategies have been put forth to nurture students' cognitive, behavioural, and personal skills. It is imperative for students to cultivate critical thinking abilities to acquire complex problem solving skills. Problem- and project-based learning (PBL) are one of the approaches that have proven successful for complex problem learning. Nevertheless, the challenge lies in ensuring the quality of problem-based learning (PBL) and managing the extended student learning time required to solve complex problem (Mat Isa et al., 2021 and Mat Isa et al., 2022). Thus, the project should be carefully designed considering the students learning time invested in solving intricate problems, as well as workload placed on the lecturer.

Practice-related learning and collaborative learning engage the students working related to real-work environment can improve the CEP and CEA, with common learning activities such as internships, industry projects, entrepreneurship, and innovation hubs (Mansor et al., 2015; Alsaleh, 2020; Sukackė et al., 2022). These learning approaches always include the collaborative work within complex setting and problems, fostering the development of communication and teamwork skills among the students (Kartom et al., 2012). Other teaching and learning strategies such as questioning techniques, literature review, class discussion, case study etc. in developing critical thinking can be found in (Alsaleh, 2020).

Methodology

Research Instrument Design

This study utilized a quantitative approach for research instrument design by adopting the online survey to collect data from the respondents. It aimed to gather comprehensive data from the respondents, i.e., 120 academic staff from 24 HLIs in Malaysia. A Cronbach reliability test was carried out during the pilot study (Azmin et al., 2024) for only 3 questions that require respondents' opinion. The result shows that the Cronbach's Alpha for the 3 item is 0.8 (>0.7 as recommended by Nunally (1970) (Nunally, 1970), thus considered as reliable. The survey was divided into four (4) sections as follows:

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Section A: Demographic Profiles of Respondents (name, faculty/school, university, email, designation, administrative post (if relevant).

Section B: Academic Background and Working Experience (level of education, experience as academician, industrial experience, number of semesters teaching the current taught courses, training programmes attended on complex engineering problems within the programme, number of EAC workshops, number of attended teaching, learning and assessment workshops).

Section C: Strategies in Implementing CEP and CEA Academic Programmes (courses incorporating CEP and CEA, frequency in assessing CEP and CEA in the programme, mapping of courses to programme outcome with CEP and CEA, awareness on CEP and EA characteristics, assessment tools used to address CEP and CEA, teaching and learning strategies used to implement CEP and CEA, teaching and learning approaches – aural, logical, physical & tactical, social, verbal, visual, solitary, naturalist, weightage/percentage used to include CEP & CEA.

Section D: Recommendation and Continual Quality Improvement (CQI) on the implementation of CEP and CEA throughout the curriculum (method of assessment, suitability of CEP and CEA to achieve the intended outcomes, effectiveness of rubrics used to assess CEP and CEA, CQI at course and programme levels, other recommendations).

This paper presents six elements that relate to the implementation of CEP and CEA under Section A to F as described and discussed in the Result Analysis and Discussion section.

Participant and Data Collection

Participants were selected from purposive sampling based on their affiliations to public and private HLIs. The invitation to participate in the survey was sent out through email, social media and the researchers' professional networks. The participants were informed about the purpose of the survey, how their data would be used, and their rights to confidentiality and to withdraw from the survey at any time. The survey was distributed in English to the participants, followed by a few reminders after the initial invitation.

The collected data was not anonymous since the participants were known; this allowed the researchers to follow up with the participants should any further information is required. The online nature of the survey allowed participants from diverse locations to participate, increasing the diversity of the data. It also gave an advantage to monitoring the responses, in which the online survey tools provide real-time data on completion rates and basic analytics, enabling researchers to monitor progress and follow up if response rates are lower than expected.

The data from the online survey was downloaded in either CSV or Excel format, then analysed using statistical software. For statistical analysis, descriptive statistics (reliability test, frequency analysis, graphs, and content analysis) were used depending on the nature of the questions and the design of the survey.

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Result Analysis and Discussion

Academic Staff Demographic

The survey respondents are academic staff from 22 public and private universities all over Malaysia, i.e. IIUM, INTI, MAHSA University, Manipal International University, UiTM, UMPSA, UniMAP, UNISEL, Universiti Malaya, Universiti Malaysia Sabah, Universiti Pertahanan Nasional Malaysia, Universiti Sains Malaysia, Universiti Tun Hussein Onn Malaysia, UTeM, UTM, First City University College, Segi University, University of Greenwich, UTAR, Universiti Tenaga Nasional, Universiti Teknologi PETRONAS, and University of Technology Sarawak. Table 1 shows the demographics of the survey respondents.

Table 1: Demographics of Respondents

Demographics					
No.	***Item***	***Percentage***	**No.**	***Item***	***Percentage***
1	**Highest level of education**		5	**Number of semesters teaching the current engineering courses**	
	Degree	2%		1 semester	2%
	Master	23%		2 semesters	12%
	PhD	75%		3 semesters	7%
				More than 3 semesters	79%
2	**Years of experience as academician**		6	**Number of trainings related to CEP and CEA within the academic programmes**	
	Less than 5 years	17%		None	7%
	Between 5 to 10 years	31%		1 time	17%
	Between 10 to 15 years	17%		2 times	17%
	Between 15 to 20 years	18%		3 times	12%
	More than 20 years	16%		More than 3 times	45%
3	**Do you hold any administrative post?**		7	**Number of EAC training attended**	
	Yes	55		None	15%
	No	48		1 time	22%
	No answer	17		2 times	11%
				3 times	15%
				More than 3 times	37%
4	**Years of experience in industry**		8	**Number of trainings related to teaching, learning & assessment**	
	None	8%		None	7%
	Less than 1 year	30%		1 time	13%
	Between 1 to 2 years	26%		2 times	13%
	Between 2 to 3 years	11%		3 times	5%
	Between 3 to 5 years	8%		More than 3 times	62%
	More than 5 years	17%			

As shown in Table I, most of the respondents (75%) hold a PhD, indicating a high level of expertise and specialization in the field of engineering. In terms of years of experience as academicians, the largest group is educators with 5 to 10 years of experience (31%). The other

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four groups consist of individuals with 10 to 15 years of experience (17%), 15 to 20 years of experience (18%), and another 16% respondents have experience of more than 20 years. The rest of the respondents (17%) are those with less than 5 years of experience. This indicates a significant presence of highly qualified and experienced academicians in the survey. In terms of administrative responsibility, almost 50% of the respondents hold some administrative duties such as Director of Centre of Excellence, Head of Programme, Head of Quality Unit and Programme Coordinator.

CEP and CEA are often associated with the solution of real-life industrial problems. The data reveals adequate industry experiences amongst the respondent to conduct CEP and CEA teaching and learning. The largest 2 groups have less than 1 year (30%) and 1 to 2 years (26%) of industrial experience. Academicians with more than 2 years of industrial experience accumulated to 36% while only 8% has none industrial experience. Note that this does not include academia who maintained active industry involvement alongside their academic roles.

The data indicates a strong representation of respondents who have taught the current engineering courses for more than 3 semesters (79%). This highlights the presence of experienced instructors who have significant familiarity with the engineering curriculum and the subject matter. In terms of training related to Complex Engineering Problems (CEP) and Complex Engineering Activities (CEA), only 7% have not attended any related training. There are 16% who have attended one training, whereas the remaining 76% have attended twice or more training sessions to be equipped and stay updated with CEP and CEA best practices. The high percentage indicated strong commitment to professional development amongst the respondents and is also indicative of the importance placed on acquiring the necessary skills and knowledge for effective teaching and learning in the respective programme and institution.

For the attendance of related training by the Engineering Accreditation Council (EAC) but not specifically related to CEP and CEA, only small percentage have not attended any training (15%). There are 22% have attended once and 63% have attended twice or more, suggesting a widespread recognition of the importance of aligning educational practices with accreditation standards. Meanwhile, only 7% has not attended any training related to teaching, learning, and assessment. Most respondents (80%) have attended twice or more related training for professional development to enhance their pedagogical skills and staying updated with effective teaching practices.

Overall, the analysis of the demographic profiles indicates a group of highly qualified and experienced academicians with adequate industrial exposure, who actively stay in tandem with the advances of the education sector through continuous professional development. They are thus most competent to plan, design and conduct teaching and learning activities for CEP and CEA in engineering programmes.

Courses Assessing CEP and CEA

Fig.1 shows the courses designed to assess CEP and CEA in the engineering curriculum. The result shows that the Final Year Project (FYP) is most used by engineering programmes to address CEP and CEA (84%). This underscores the significance placed by programme owners on the FYP course for students to apply their knowledge and skills acquired throughout their engineering education to a research-based project, enabling them to demonstrate their abilities in undertaking complex engineering problems solving and complex engineering activities. The

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Integrated Design Project (IDP) and design courses are also popularly used by engineering programmes to address CEP and CEA based on the respondents' feedback (83%). This reveals the importance of design-oriented approaches in evaluating students' proficiency in CEP and CEA. The findings are similar to the previous study (Mat Isa et al., 2021), where complex engineering activities were found to be addressed in Final Year Project, Industrial Training and Integrated Design Project and laboratory courses. In the present study, 55% respondents indicated the use of laboratory courses to address CEP and CEA.

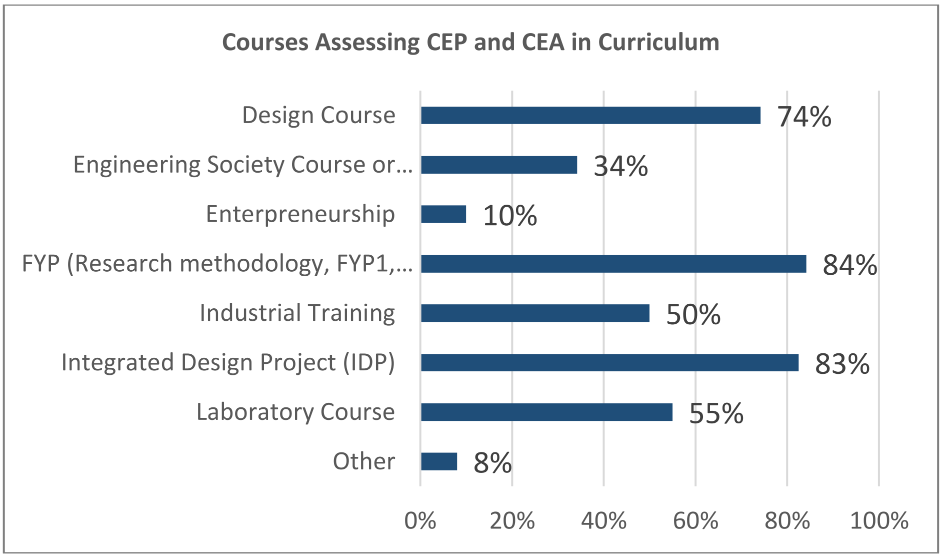

Figure 1: Courses Assessing CEP and CEA in Curriculum

Frequency of CEP and CEA Assessment

Fig. 2 shows the frequency of CEP and CEA assessment in engineering programmes. The implementation of CEP and CEA assessment are predominantly conducted every semester (81%). The planned assessment every semester indicates the significance placed on regular evaluation and monitoring of students' progress in the development of CEP and CEA skill in related subjects throughout the academic study. The curriculum thus allows students to continuous be exposed to CEP and CEA to hone the skill under different subjects and the guidance of different lecturers. It also provides opportunity for timely intervention should the student perform poorly.

There are 10% respondents which indicated assessment of CEP and CEA only in the engineering final year. This approach focuses on comprehensive evaluation of the skill prior to student graduation only. Students should have acquired CEP and CEA concepts and skill throughout their engineering programme and are expected to demonstrate their attainment in the related assessment in the final year courses and the culminating courses.

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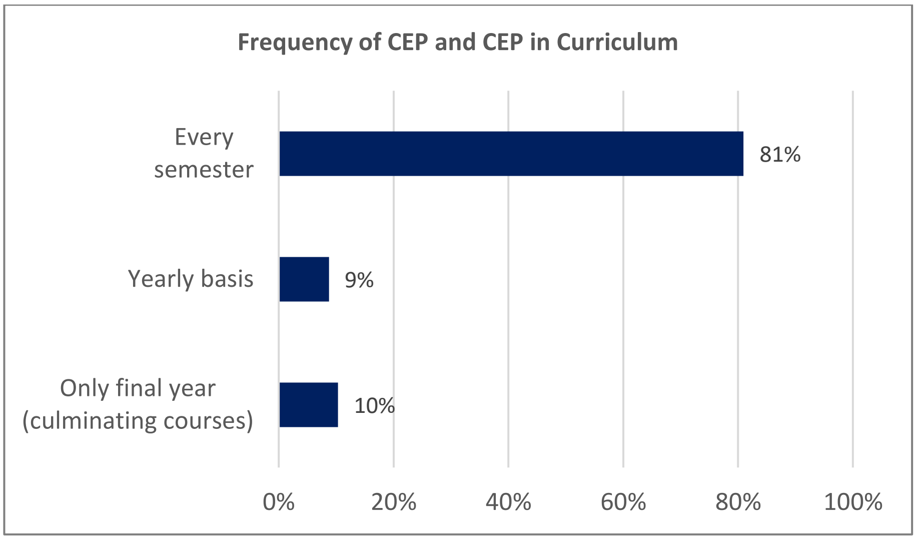

Figure 2: Frequency of CEP and CEA in Curriculum

A smaller percentage of respondents (9%) indicated yearly assessments of CEP and CEA. In this approach, the assessment is spread out over the academic years but not necessarily in consecutive semesters. While less common, the phased assessments provide opportunity for interim review and intervention to facilitate the progressive development of the skill amongst the students.

Teaching and Learning Strategies to Foster CEP and CEA in Courses

Fig.3 indicates problem-based learning (PBL) as the most widely used teaching and learning strategy for CEP and CEA, with 77% of respondents using this method in their implementation. PBL is an instructional approach that engages students in solving real-world problems, encouraging active participation, critical thinking, and the application of knowledge. This strategy aligns well with the nature of CEP and CEA, as it promotes hands-on learning and problem-solving skills development. Academicians need to teach thinking and augment problem-based learning due to the students' different levels of motivation, different attitudes about teaching and learning and different respondents to specific classroom environments and instructional practices (Boon et al., 2022). Mohamed Isa (2024) proved that problem- and project-based activities have the potential to increase the quality of learning in STEM subjects.

Discussion-based approaches are also popular, with 63% of the respondents emphasizing the importance of discussions in teaching CEP and CEA. Discussions provide a platform for students to exchange ideas, share perspectives, and deepen their understanding of complex concepts. By facilitating dialogue and encouraging active engagement, discussions promote critical thinking, collaboration, and the exploration of different solutions and perspectives.

Collaborative learning (Coll-L) is used by 42% of the respondents as a teaching and learning strategy. This strategy allows students to work together in groups or teams to solve problems, complete projects, or engage in activities. This approach fosters teamwork, communication skills, and the sharing of knowledge and expertise among students. Coll-L is particularly relevant to CEP and CEA, as these domains often require interdisciplinary collaboration and integration of different perspectives.

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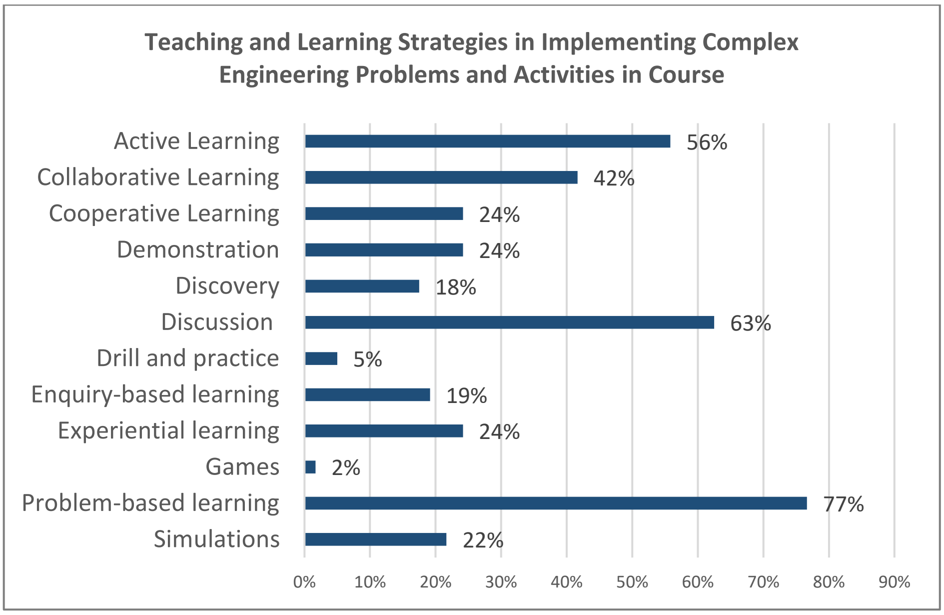

Figure 3: Teaching and Learning Strategies in Implementing CEP and CEA in Courses

Active learning (AL) is adopted by 56% of the respondents as a strategy for teaching CEP and CEA. Active Learning involves engaging students in hands-on activities, experiments, simulations, or practical exercises. This approach promotes student participation, critical thinking, and the application of knowledge in real or simulated contexts. AL is well-suited for CEP and CEA, as it allows students to experience the practical aspects of these domains and enhances their problem-solving skills.

Cooperative learning (Coop-L) is employed by 24% of the respondents. It emphasizes working together in structured groups to achieve shared learning goals. This strategy promotes teamwork, communication, and the development of social skills. Although it is less common, it can still be a useful approach in fostering collaboration and knowledge sharing in the context of CEP and CEA.

Although game-based learning (GBL) is employed by only 2% of the respondents, Chumari et al., (2024) have shown that GBL can incorporate core educational environments to improve learning outcomes such as problem-solving skills and interactive gameplay that mirror traditional gaming environments, making learning processes both enjoyable and effective.

Assessment Tools Used to Address CEP

Fig. 4 reveals a diverse range of assessment tools employed to address CEP in the engineering programmes. The findings show the prevalence of project-based assessments to address CEP (88%). A well-designed project work provides students with opportunities to tackle complex problems and engage in complex engineering activities, fostering development of their related problem-solving skills.

CEP is also widely incorporated into assignments (63%). Assignments provide structured tasks that assess students' abilities to analyze and solve complex problems and engage in complex engineering activities, allowing them to demonstrate their attainment through written or practical work. The other common tools are problem-based learning (PBL) and case studies which are employed by 48% of the respondents in their programmes, offering students real-

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world scenarios and complex engineering problems to analyse and solve. These assessment methods encourage critical thinking, decision-making, and the application of knowledge in authentic engineering contexts.

Previous study showed that most of the programmes in Malaysia addressed complex engineering problems in assignments or projects, but less so in final examinations and mid-term tests (Mat Isa et al., 2021). In the present study, the results show that 38% of the respondents uses the final examination and 20% used test as an assessment tool for CEP. This suggests the employ of examination question and answer scheme to provide comprehensive evaluation of students' attainment in complex problem solving. Presentation-based CEP assessments are also used by 37% of the respondents. This tool requires students to effectively communicate their understanding and solutions to complex engineering problems using verbal and visual medium. Other tools less commonly employed are laboratory, community-based learning, test, etc.

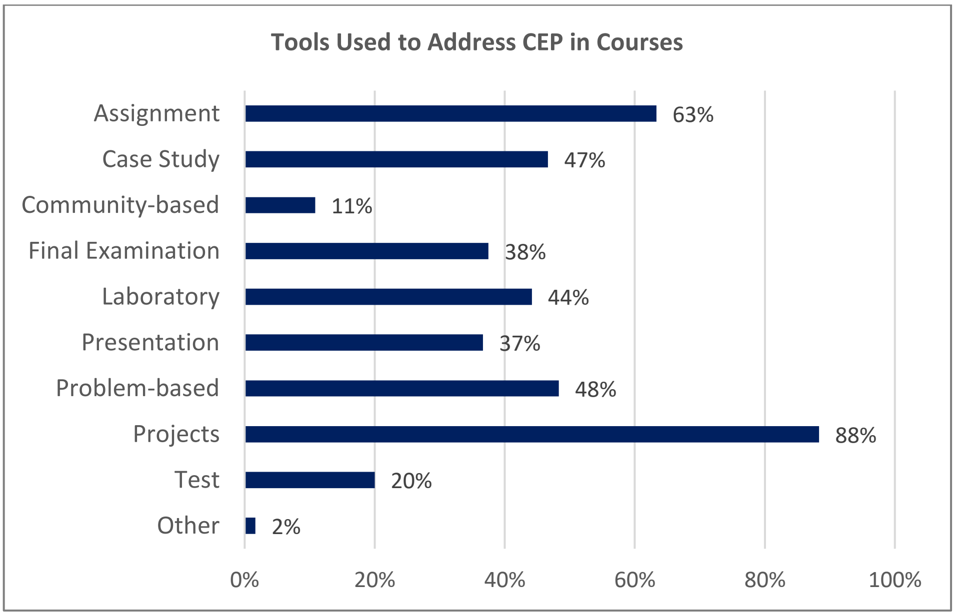

Figure 4: Tools Used to Address CEP in Courses

Assessment Tools Used to Address CEA

While CEP focuses on the cognitive domain, CEA is concerned with the affective domain. Fig. 5 reveals that the most used assessment tool for CEA is the final year project (70%) that provides students with an opportunity to apply their knowledge and skills to a comprehensive investigative project. This assessment tool allows students to manage a range of resources, innovate and demonstrate their life-long learning ability. In addition, communication forms an important part of the assessment, both in terms of technical reporting and technical presentation. Next widely utilised tool to address CEA is the capstone project or Integrated Design Project (IDP) course (65%). IDP involves the integration of multiple civil engineering sub-disciplines to solve complex design problems. This assessment method also emphasizes the practical application of engineering knowledge in a collaborative setting. Additionally, assignments, laboratories, problem-based, and presentations are used by 38% of respondents.

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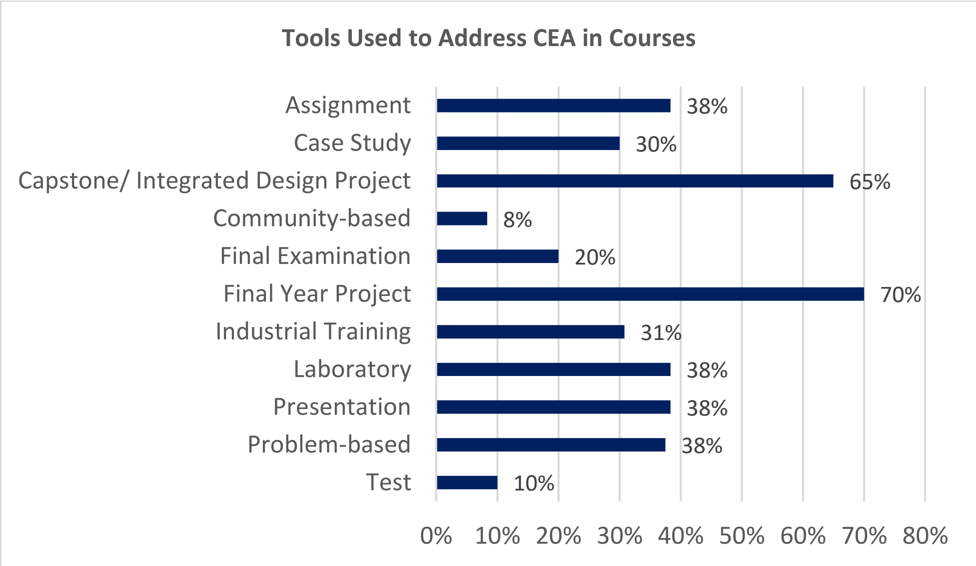

Figure 5: Tools Used to Address CEA in Courses

Note that many of the CEA assessment are done in group teaching and learning activities. These CEA assessment tools are characterised by interaction and communication, both within the group assigned, as well as with external parties (e.g. community, society). Previous study shows that students are receptive to carrying out tasks in small group, satisfaction with the evaluation through presentations and receive new knowledge (Kamaruddin et al., 2012). CEA assessments also often contain the element of familiarity of issue, where students are given an activity setting not previously encountered to facilitate and stimulate the learning process.

Conclusion and Recommendations

This paper presents the current practice in the implementation of complex skillsets, namely complex engineering problems (CEP) and complex engineering activities (CEA) amongst engineering programmes in Malaysia. The test indicates that the survey instrument is reliable to be used in the main study. The findings include the courses selected to assess CEP and CEA, the basis of frequency in the assessment, the assessment tools used, and the teaching and learning strategies used to address the CEP and CEA in the courses throughout the engineering curriculum. Culminating courses such as Final Year Project, Integrated Design Projects, and related design courses having prominence of project-based learning are most used to address CEP and CEA. Various assessment methods are reported to be used in line with the evolving high education landscape. The combination of project-based learning, assignments, problem-based learning, case studies, final exams, and presentations contributes to a comprehensive evaluation of students' competencies in critical engineering domains. Regular CEP and CEA assessment every semester is the most popular, which allows for continuous feedback and reflection to support students' ongoing growth. Respondents' choice of CEP and CEA teaching and learning strategies reflect an emphasis on student engagement, active participation, collaboration, and practical problem- solving. These strategies aim to create a learner-centred environment that facilitates the acquisition of knowledge, skills and competency in the complex engineering domains.

Limitations and Recommendations for Future Research

The study involved responses from 120 academic staff across 24 higher learning institutions, which may not fully represent the diversity of engineering programs in Malaysia. The reliance on self-reported survey data could introduce bias, as participants may overestimate their programs' effectiveness in implementing CEP and CEA. In addition, the study primarily focuses on project-based and problem-based learning, potentially overlooking other innovative assessment tools and methods that could be employed.

Future research should consider a larger and more diverse sample of institutions and educators to provide a more comprehensive understanding of CEP and CEA implementation across Malaysia. Longitudinal studies can be conducted to assess the long-term impact of CEP and CEA implementation on students' skills and career success, providing insights into the effectiveness of different teaching and learning strategies over time. In addition, in-depth case studies can be explored based on specific institutions or programs that have successfully integrated CEP and CEA, highlighting best practices and lessons learned that can be shared with other institutions. Finally, future research may investigate the use of alternative assessment methods, such as digital simulations and peer assessments, to provide a more comprehensive evaluation of students' abilities to tackle complex engineering challenges

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