EDUCATIONAL REFORM IN ENGINEERING: UNDERSTANDING STRUGGLES OF STUDENTS IN SOLID MECHANICS

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Received: 22 April 2025
Accepted: 26 May 2025

ABSTRACT

Diploma in Civil Engineering Programme (CEEC110) offered by Universiti Teknologi MARA is an accredited engineering technician education programmes approved by Engineering Technology Accreditation Council (ETAC), Malaysia. The attainment of programme outcomes (PO) by individual student at the end of their candidature must satisfy a minimum requirement stated by ETAC i.e. scored at least 50% in each PO. Monitoring PO and course outcomes (CO) at course level is conducted every semester in the faculty, and the current situation has revealed that attainment of CO-PO in the Solid Mechanics course is a cause for concern. Therefore, this study aims to identify the lowest achievement of CO-PO in Solid Mechanics course and its corresponding assessment. Results show that attainment of CO2-PO2 is the lowest in final exam assessment throughout the studied semesters. Syllabus contents under CO2-PO2 (statically determinate beam) were discussed, and a case study was conducted to investigate the reasons of poor performance in solving problems related to beam questions in the final exam. Subsequently, effective teaching and learning of Solid Mechanics are discussed and suggestions on strategy to improve students' final exam score are made.

Keywords: Assessments, Course outcomes, Final exam, Programme outcomes, Solid mechanics

1.0 INTRODUCTION

Solid Mechanics or Mechanics of Materials is a discipline that studies materials and structures and how they deform under different loads. In universities, Solid Mechanics is a fundamental core course in engineering, particularly for civil and mechanical engineering students and this subject is compulsory to be enrolled by students during their first year of candidatures. By mastering Solid Mechanics, an engineer or a student is able to apply the principles of statics to determine the forces acting on or within solid body when designing any structures or machine. Other than that, structural behaviour such as strains, deflections and rotations are crucial to be determined and checked against specified design codes to ensure a safe and adequate structure has been designed and built. Through the study of Solid Mechanics, students are able to understand how the size of member and the strength of materials can affect stability, load carrying capacity, deformations and failure modes of any structure or machine.

At diploma level, Solid Mechanics usually covers topics on stress and strain, mechanical properties of materials, axial load and deformation, resultant internal forces, bending of beam, transverse shear of beam, torsion and buckling of column. For Diploma in Civil Engineering program (CEEC110) in Universiti Teknologi MARA (UiTM), Solid Mechanics is offered for students during the second semester (i.e. in the first year) of their three years diploma programme. In order to help students to gain better understanding on Solid Mechanics, pre-requisite is set by faculty i.e. students must pass the course Fundamental of Physics during their first semester. On the other hand, a student who has passed Solid Mechanics is eligible to register for Basic Structural Analysis on the following semester.

Implementation of outcome based education (OBE) by Faculty of Civil Engineering UiTM has emerged since 2007 (Ismail et al., 2010). In Malaysia, Engineering Technology Accreditation Council (ETAC) is the body delegated by board of Engineers (BEM) for accreditation of engineering technology degrees and engineering technician qualifications such as diploma level. The objective of accreditation is to ensure that graduates of the accredited engineering technician education programmes satisfy the minimum academic and practical requirements for registration as engineering technicians or inspector of works with the BEM (Standard, 2024). Based on the latest ETAC standard, there are eleven (11) programme outcomes that students need to attain by the time of graduation. Basically, those skills, knowledge and behaviour can be classified knowledge (PO1), problem analysis (PO2), design of solutions (PO3), investigation (PO4), tool usage (PO5), the engineering technician and the world (PO6), ethics (PO7), individual and collaborative team work (PO8) communications (PO9), project management and finance (PO10) and life-long learning (PO11).

Among eleven POs mentioned above, the course Solid Mechanics (ECS226) is more relevant to knowledge (PO1) and problem analysis (PO2) as these POs require cognitive style by an individual to process data, thought, remember, and solve problems consistently and long-lasting (Adnan, 2021). At course level, this subject has defined two outcomes that require students to achieve after completing the course. Table 1 shows the CO-PO mapping for this course and their assessments. The course outcome (CO1) is mapped to the PO1 and the CO2 is mapped to the PO2, both are in the same weightage in terms of assessment. As can be seen in Table 1, assessments such as assignment, test and final exam are measuring 50% of each PO. For any accredited engineering programme, it is expected that all students need to attain a minimum of 50% in all the eleven POs as above-mentioned by the time of graduation. The attainment of POs for students is only can be calculated based on the average performance after completing all the courses. However, monitoring at course level is important to ensure the minimum requirement of ETAC in PO achievement is fulfilled. Every semester, one of the responsibilities for lecturers teaching in the Faculty of Civil Engineering, UiTM is to evaluate the attainment of COs and POs achieved by students in every course, so that continual quality improvement and remedy action can be taken to improve the attainment of students' POs.

From the data available, among all courses in the programme CEEC110, Solid Mechanics is one of the critical course that the averages achievement of CO-PO was sometimes below minimum i.e. less than 50% at course level. Moreover, study by Wee et al (2021) has shown that the failure rate of this course was 65% and 37% for semester March-August 2018 and semester March-August 2019, respectively. Therefore, this study aims to investigate in detail on which part of the assessment shows the lowest attainment of CO and PO. The objectives of this study are as follow:

1. To assess the performance of students in attaining CO-PO in Solid Mechanics course for academic years spanning from 2018 to 2024.

2. To identify the weaknesses of students in solving Solid Mechanics problems based on the lowest attainment of CO-PO and its corresponding assessment.
3. To discuss strategies and actions to be taken to improve the teaching and learning of Solid Mechanics for undergraduate diploma students.

Table 1. Mapping of CO-PO and assessment for ECS226

	PO1: Apply knowledge of applied mathematics, applied science, engineering fundamentals and an engineering specialisation as specified in DK1 to DK4 respectively to wide practical procedures and practices.	PO2: Identify and analyse well-defined engineering problems reaching substantiated conclusions using codified methods of analysis specific to their field of activity (DK1 to DK4)	Assessment (Total 100%)
CO1: Apply basic understanding of stresses and strains in solid body, beam, shafts and column.	CO1-PO1		Assignment (10%) Test (10%) Final Exam (30%)
CO2: Develop solutions for problems related to statically determinate beams. (PO2)		CO2-PO2	Assignment (10%) Test (10%) Final Exam (30%)

2.0 METHODOLOGY

This study is conducted by using mixed research methods which involved both quantitative (longitudinal study to trace the pattern change on the achievement of CO-PO) and qualitative (a case study). **Fig. 1** shows the flow sequence to achieve the objectives of this study. Data of CO-PO was obtained from the Revolution on Assessment for Student Monitoring System (i-RAS) faculty. As an accredited engineering programme, lecturer in charge for each course is required to fill in and compile the marks and grading for each assessment in i-RAS during the end of each semester. In the i-RAS system, the average of CO-PO attainment at course level will be auto generated after lecturer in charge has compiled all data from all groups.

Solid Mechanics course is offered by the faculty in every semester at alternate huge and small amount of students. Normally, semester March-August is considered as huge amount of students' semester and this is taken into consideration of this study. Hence, for a better comparison, data from semester March-August 2018 to semester March-August 2024 were employed in this study. There were total seven (7) semesters in the data analysis, and among three types of CO-PO assessments, the lowest CO-PO attainment is to be identified. Meanwhile, a detailed investigation about complexity of the topics covered under the weakest performing assessment is conducted. A case study on one of the sample of the weakest performing assessment is presented and thereafter, suggestions are made to improve the attainment of CO-PO in that particular assessment.

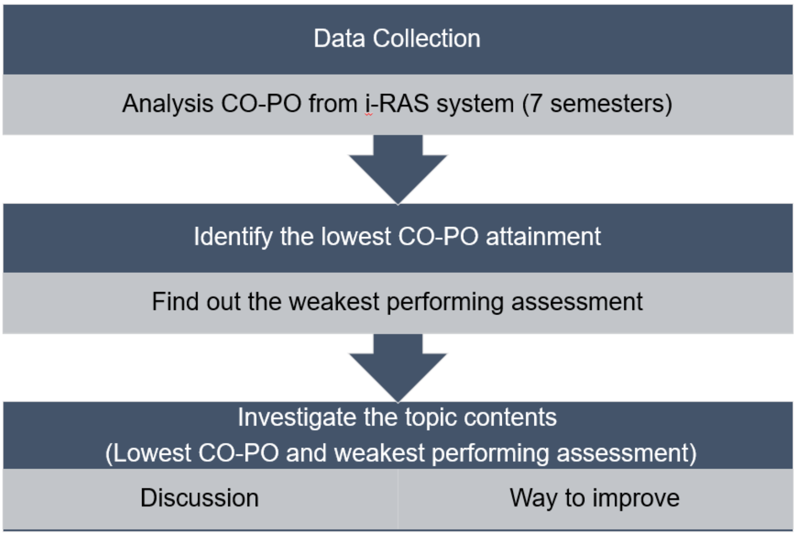

***Fig. 1** Flow sequence*

3.0 RESULTS AND DISCUSSION

3.1 Attainment of CO-PO

Table 2 shows the attainment of CO-PO for Solid Mechanics ECS226 in UiTM Johor Pasir Gudang campus during academic years (2018 to 2024). The assessment and grading of this course are based on 40% formative (assignment and test) and 60% summative (final exam). Basically throughout all semesters, attainment of CO1-PO1 and CO2-PO2 are in the satisfactory level in assignment. It is worthy to mention that for semester Mar-Aug 2021 (semester ID 20212), achievement of CO-PO in assignment was slightly lower compared to other semesters. This may due to the higher level of difficulty of the task set in the assignment during the period of post covid-19 pandemic. For that semester, there was no physical final exam conducted, all tests and exam were conducted online. Besides assignment, students did not perform well in both test and exam for those semesters having physical classes, test and exam. For semesters before covid-19 pandemic, even though achievements of CO1-PO1 in test were satisfactory, but this result is found to be less positive for CO2-PO2 in the test as well as in the final exam. After recovery from post covid-19, physical classes, test and exam took places during semester 20232 and 20242. The attainment of CO1-PO1 and CO2-PO2 was below 50% in both test and final exam.

Table 2. Attainment of CO-PO for Solid Mechanic Course ECS226

Semester ID	Duration/Year	Total students enrolled	Course Outcome-Programme Outcome (CO-PO)	Attainment of CO-PO in Assignment (weightage 20%) By Group	Attainment of CO-PO in Test (weightage 20%) By Individual	Attainment of CO-PO in Final Exam (weightage 60%) By Individual	Remark
20182	Mar-Aug/2018	240	CO1-PO1	92	50	49	Physical classes, test & exam
			CO2-PO2	92	49	45	
20192	Mar-Aug/2019	293	CO1-PO1	86	57	51	
			CO2-PO2	81	42	32	
20202	Mar-Aug/2020	176	CO1-PO1	86	59	46	COVID 19-Pandemic (online classes, test & exam)
			CO2-PO2	87	48	36	
20212	Mar-Aug/2021	123	CO1-PO1	63	83	61	Hybrid lecture (physical + online classes, online tests & exam)
			CO2-PO2	58	73	40	
20222	Mar-Aug/2022	186	CO1-PO1	77	90	58	
			CO2-PO2	81	88	48	
20232	Mar-Aug/2023	108	CO1-PO1	93	44	47	Physical classes, test & exam
			CO2-PO2	89	27	42	
20242	Mar-Aug/2024	104	CO1-PO1	82	49	44	
			CO2-PO2	86	43	44	

Overall, the average achievement of CO2-PO2 in the assessment of final exam for Solid Mechanics has never satisfy the minimum requirement by ETAC at course level. As can be seen from **Fig. 2**, data showed that the achievement of CO2-PO2 in final exam throughout seven semesters were consistently below 50%. In addition, test results also show that attainment of CO2-PO2 were critical for semesters 20182, 20192, 20202, 20232 and 20242. These indicate that students experienced the biggest challenge in problem analysis (PO2) and develop solutions for problems related to statically determinate beams (CO2).

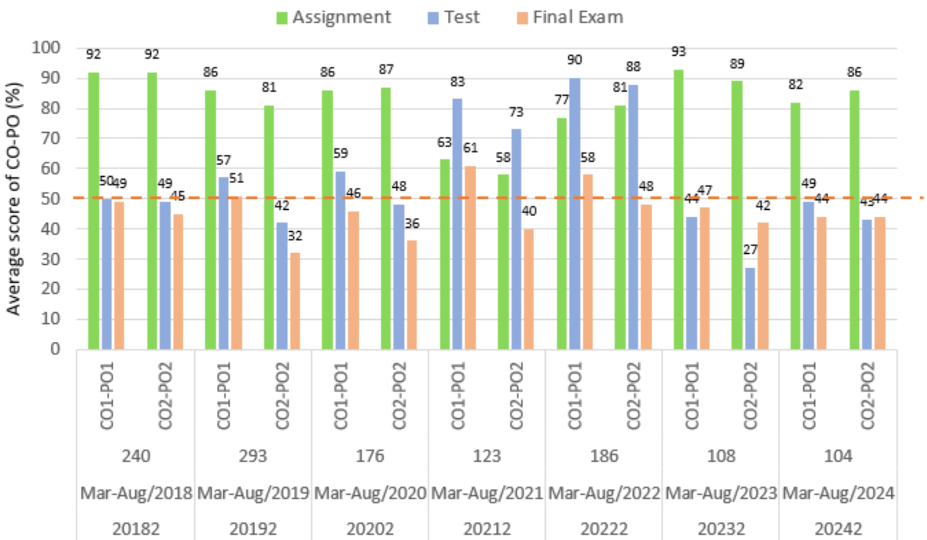

***Fig. 2** Average score of CO-PO and comparison with passing mark 50%*

Table 3 shows the distribution marks that counted in the measurement of CO-PO on each topics in the assessments of test and final exam. It is found that CO2-PO2 was mainly contributed by topic 2, stresses and deflection of statically determinate beams. Aligned with its weightage in the overall assessment, this topic is allocated for 7 weeks (out of 14 weeks) for lecturers to conduct teaching and learning activities and it usually falls in week 5 to week 9 during the semester. The content of this topic consisting of identifying statically determinate beam and find out support reactions for different type of supported beams. Once identify the type of support reactions on the beam, students need to apply three static equilibrium equations i.e. the summation of forces in X and Y directions must be equal to zero and the summation of moment taking at one base point must be equal to zero to calculate support reactions of the beam. Students are then taught about finding internal forces (axial, shear and moment) at any cutting point or section of the beams, again, this process requires the ability of students to draw a correct free body diagram, identity the unknown forces and apply static equilibrium equations. After obtaining the required internal forces such as shear forces and bending moments at some critical points, a complete shear force diagram and bending moment of the beam can be drawn. In the stage of constructing shear force and bending moment diagram, students are expected to understand the relationship of external loadings and shear forces, and relationship between shear force and bending moment throughout the segment of a beam. By plotting a perfect shear force and bending moment diagram, critical or maximum shear force and bending moment can be identified, and this information are really matter as the input of design to any beam structure. In addition, the maximum shear force and bending moment values will be used to determine shear stress and bending stress distribution across the beam section.

Table 3. Distribution of CO-PO marks in each topic

Distribution of CO-PO marks in Test						
CO	PO	Topic 1 Stress and strain	Topic 2 Stresses and deflection of statically determinate beams	Topic 3 Torsion of circular shafts	Topic 4 Elastic Buckling of column	Total
CO1	PO1	50	-	-	-	50
CO2	PO2	-	50	-	-	50
						100
Distribution of CO-PO marks in Final Exam						
CO	PO	Topic 1 Stress and strain	Topic 2 Stresses and deflection of statically determinate beams	Topic 3 Torsion of circular shafts	Topic 4 Elastic Buckling of column	Total
CO1	PO1	30		10	10	50
CO2	PO2		50			50
						100

In beam design, it is essential for a structural engineer to compare the maximum shear stress and bending stress to limiting stresses stated in the design guideline such as British standard and Eurocodes. Since the effect of geometric, shape and size of the beams play important roles in the shear stress and bending stress of a given beam, students are required to master the knowledge on how to determine the center of gravity as well as moment of inertia of the given shape and size of the beam section. As the last sub-topic, students are taught one of the method – Macaulay’s method to determine deflection or rotation of any point on a beam. Deflection checking is one of the serviceability limit state requirement adopted either by British standards or Eurocodes. Therefore, this topic is vital for undergraduate student to develop the sense of deflection analysis in beam design This topic explains step by step from double integration of a moment function to the development of the slope or rotation function as well as to the deflection function. In order to establish the full rotation and deflection functions, students are required to have a good visualization about the boundary conditions for different types of beam supports. For example, the deflection and rotation at the fixed end support are zero, while for a roller or pin support only deflection is equal to zero. Indeed, this process involves the illustration of elastic curve that resembles the behaviour of beams under flexural.

The contents of topic 2 are planned carefully and the continuity of the syllabus can be seen from Table 4, as indicated in remarks. It is important to mention that remark R1 i.e. support reactions calculated at the beginning of this topic is the most basic knowledge that students need to master well. Any misconception of taking moment at a support of the statically determinate beam would incur mistake or error in determining support reactions. If the support reactions are inaccurate, students are not able to get a right shear force diagram as well as bending moment diagram as remarked R2. Hence, the incorrect shear force and bending moment reading would affect the result of shear stress and bending stress across the beam section. The sequence of errors definitely affects the final outcome of the beam analysis. On the other hand, accuracy in finding moment of inertia (remark R3) is really matter when the question involves finding bending stress and shear stress across the beam section.

5 Syllabus content in topic 2 Solid Mechanics

Topic	Syllabus content	Remarks
2.1	Types of beam support, degree of indeterminacy, support reactions of statically determinate beam (SDB)	Identify unknown support reactions based on the type of support, determine the support reactions (R1).
2.2	Internal forces (axial, shear and moment) of SDB, shear force diagram and bending moment diagram of SDB	Support reactions from 2.1 (R1) in order to get shear function and moment function (in terms of x). The functions of shear and moment enable to plot shear force diagram and bending moment diagram (R2).
2.3	Center of gravity and moment of inertia of the beam section	Center of gravity in order to get the moment of inertia (R3) for unsymmetrical section.
2.4	Bending stress and shear stress of SDB Bending stress and shear stress distribution across the beam section	Moment of inertia from 2.3 (R3) to calculate the bending stress and shear stress across the beam section. The value of bending moment and shear force obtained from 2.2 (R2) are used to find the bending stress and shear stress.
2.5	Deflection and rotation of SDB by using Macaulay's method	Support reactions from 2.1 (R1) to establish moment function using Macaulay's formula.

3.2 Case Study: Analysis of final exam scores in the beam questions

In order to support the above-mentioned issue, analysis on the average scores by students in solving problems of beam analysis is carried out. Only semester 20242 was considered in this analysis and the beam questions that involved measuring CO2-PO2 can be found in Question 2 and Question 3 (**Fig. 3** and **Fig. 4**). Question 2(a) is purely on finding support reactions and sketch the shear force and bending moment diagram of the beam. Ten (10) marks was allocated for this sub-section. Then given another types of beam, students are required to determine deflection of the beam by using Macaulay's method and students are gaining 20 marks for this Question 2(b). Question 3 is worthy to be granted 20 marks if students are able to complete the whole question. For the first part, students need to back calculate the unknown uniformly distributed load by the given support reaction at one end of the beam. Secondly, students are required to back calculate the required cross-sectional area of the I-section beam by a given allowable bending stress, along with the proportionate width, height and thickness of the I-section. Since there were three different types of beams were set in the final exam, so students can avoid sequencing errors that caused by support reactions. However, students are required to carry out the process of taking moment at one of the beam support either to find support reactions for Question 2(a) and Question 2(b) or to back calculate unknown uniformly distributed load for Question 3 as the first step of solution.

It is worthy to mention that the total of students sitting for this final exam was about 104. The average marks scored by students in Question 2(a), Question 2(b) and Question 3 can be seen in Table 5. Students managed to gain 5.57 out of 10 marks for Question Q2(a). This question is straight forward, categorized as cognitive level 3 (application) as in Bloom's taxonomy. Time allocation was suggested as 18 minutes based on the weightage of mark carrying. Some students were not able to apply the correct concept of taking moment such as making errors when considered the lever arm or center of gravity for triangular distributed load. In addition, this could possibly due to the lack of practice in taking moment for various kind of load combinations. For Question 2(b), students scored almost half of the designated mark i.e. 9.98% out of 20%. This is a cognitive level 4 (analysis) in Bloom's taxonomy question which required students to analyse the deflection of beam by using Macaulay's method. Before establishing the moment function, support reaction at support B is first to be found. Even though only single load case imposed on the overhanging beam and the total internal moment in the beam is simple, but most of the student showed lack of understanding on the boundary condition of the overhanging beam. Thus, constant values are incorrect for the deflection function and led to the wrong answer of deflection. Suggested duration of answering this question was 36 minutes according to the weightage of mark carrying. Only high performing students were able to complete the solution for this question.

On the other hand, the most challenging cognitive level 5 (synthesis) was set for Question 3. Most of the students did not complete the solution for this question, some of them have worked out until solving the value of unknown uniformly distributed load only. This question has marked as the most difficult question in the final exam semester 20242 due to its higher cognitive demand as well as time consuming. Suggested time for solving this was 36 minutes. In summary, the average mark scored by students in the beam questions as part of final exam semester 20242 is 21.83/50, which is equivalent to 44% out of 100%. As mentioned above, this score represents the attainment of CO2-PO2 for Solid Mechanics in semester 20242, and it can be verified through Table 2.

QUESTION 2

a) **Figure Q2(a)** shows a cantilever beam ABC with a length of 3 m, which carries a triangular load of 10 kN/m and a concentrated load of 5 kN at point A. Compute all the support reactions at point C. Hence, sketch the shear force and bending moment diagrams for the beam. (CO2-PO2)(C3)

(10 marks)

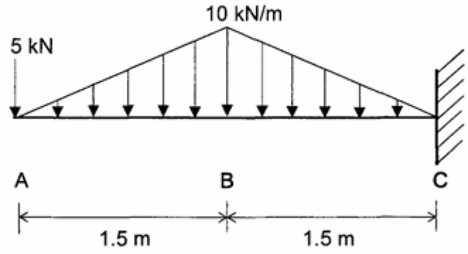

Figure Q2(a)

b) The overhanging beam ABC is roller supported at point B and pinned at point C and subjected to a concentrated load of 20 kN at point A as shown in **Figure Q2(b)**. Calculate the vertical deflection of the beam at point A using the Macaulay's method. Take modulus of elasticity, E = 200 GPa and moment of inertia of the beam, $I_{xx} = 5 \times 10^{-4}$ m^4. (CO2-PO2)(C4)

(20 marks)

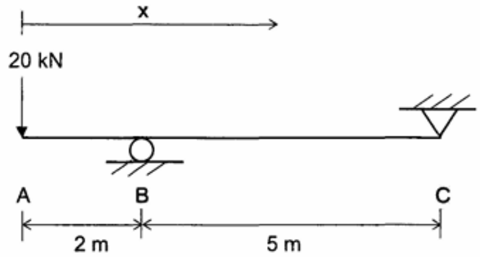

Figure Q2(b)

Fig. 3 *Question 2 Part of Final Exam Solid Mechanics Semester 20242*

QUESTION 3

Figure Q3 shows the proposed simply-supported steel beam ABCD of 6 m long for a single-storey warehouse building. The beam carries two equal concentrated loads of 5 kN each at points B and C, and a uniformly distributed load, *w* of unknown value. Provided the vertical support reaction at point A is 30 kN. (CO2-PO2)(C5)

i) Find the value of unknown uniformly distributed load, *w*.
ii) Evaluate the required cross-sectional area for the I-shape beam as shown in **Figure Q3**. Take allowable bending stress, σ_{all} = 0.5 kN/mm^2.

(20 marks)

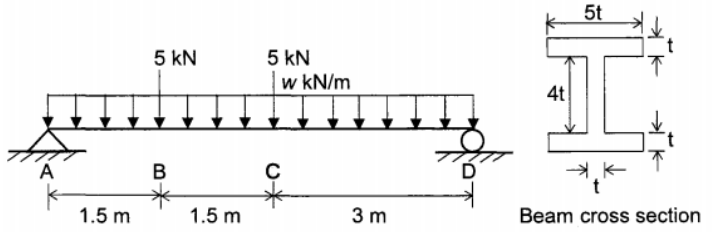

Figure Q3

Fig. 4 *Question 3 Part of Final Exam Solid Mechanics Semester 20242*

Table 5. Average mark scored by students in the beam questions final exam (Case study)

Question in the final exam	Q2(a)	Q2(b)	Q3	Total
Full mark	10	20	20	50
Average mark scored by students (in 50%)	5.57	9.98	6.28	21.83
Expected duration to complete each task (minutes)	18	36	36	90
Average mark score by students (in 100%)		44		

Some key findings can be found from this case study.

i) Most of the students were unable to develop solutions for problems related to statically determinate beams in final exam. Meanwhile, they were also unable to analyse well-defined engineering problems. These may attribute to the complexity of the topic content and lack of deep understanding about the topics.
ii) Most of the students were unable to complete solutions for the beam questions due to time-constraint. No marks can be given if students left the answers or solutions blank. In this sense, time management in solving final exam questions play important role in achieving better result.

These findings are further supported by a survey conducted by Wee et al. (2021), in which from the perspective of students, they strongly agreed that they had little time to acquire a deep understanding of this course and the final exam questions were too lengthy and tedious for diploma level.

3.3 Effective Teaching and Learning on Solid Mechanics Course

This section discusses the effective teaching and learning on Solid Mechanics from literature and emphasis on the topic of statically determinate beams. Suggestions on possible ways to improve the attainment of CO2-PO2 (problem analysis) for Solid Mechanics at course level are made.

Active learning is deemed as the most effective strategy to learn Solid Mechanics for diploma students. To facilitate active learning, lecturers may adopt physical models (Giancaspro & Arboleda, 2019) to demonstrate moments, bending and shear forces. This fun classroom demonstration has improved students learning experience based on a survey feedback from students. On the other hand, flipped classroom approach has been studied by Ryan and Kirn (2015) for an introductory course in Solid Mechanics. Their research found that lower performing students have better learnt compared to high achieving students by using flipped classroom approach. In order to enhance student understanding about theoretical concepts of Solid Mechanics, some practical lab hands-on (Leser et al., 2014; Lucke 2012) can be planned in the teaching and learning activities. For instance, beam bending test in the lab would be essential to assist students in understanding the elastic curve or deflected shape of the beam under different types of support. Small group tutorial class is an effective way to encourage active learning and improve the quality of student's learning (Zhang & Yang, 2015). Small group discussion can boost the confidence level of students in understanding the difficult topics in Solid Mechanics. Even though self-study is essential for students to develop independent learning but collaborative learning among peers is able to engage students in a more fun learning process.

In most of the engineering degree programme, Static course is introduced before Solid Mechanics course to establish students' basic fundamental of science and mathematics. Unfortunately, Static course is not designed under this curriculum and the transition of students from secondary to tertiary education making most of them facing great challenge in visualization the behaviour of structures under different types of loading. Leser et al. (2014) and Chaphalkar and Blekhman (2007) suggested that the use of software tool or finite element analysis that simulate the axial, bending, shear and torsion of solid body can help students to visualize and understand structural and material behaviour, hence enhance students' learning outcomes. Rather than boring classroom lecture, new century of students may prefer interactive mobile learning apps to stimulate active learning. Students can visualize complex questions, create unlimited practice examples to consolidate the knowledge and connect various concepts with an overall picture of the course through the interactive mobile learning apps (Jiang et al., 2018).

Co-teaching strategy by Motaref and Hain (2024) has been adopted in University of Connecticut for Solid Mechanics course, both instructors need to attend all lecturers, one giving lecture and leading classroom while another one engaged with students, provided feedback, encouraged collaborative among students. Students had positive responses by having two instructors whose enriched their learning experience by offering multiple teaching perspectives as well as immediate assistance or feedback regardless in classroom or outside classroom. In order to relate practical example of applying Solid Mechanics in real-world engineering projects, competent lecturers who have industrial working experience or experienced lecturers are preferred to be engaged in teaching Solid Mechanics. Students can see the big picture on applications of Solid Mechanics in real-world, indirectly appreciate the important of problems analysis for this course and thus stimulate their interest in this course.

The effectiveness of the above mentioned teaching and learning strategies have been proven and if some of them can be adopted by the faculty, students are feasible to get deeper understanding on this course. Nevertheless, preparation or readiness of students in facing final exam is crucial to the authors' point of view. Result of this study has shown that students were unable to complete or solve the beam questions during final exam especially the highest difficulty level beam question. Since final exam covers 60% of the course score, therefore, there is a need to train students always well versed on time management in solving problems of Solid Mechanics. It is commonly agreeing that the more exercises, tutorial, past exam questions attempted by students, the more self-efficacy can be developed and hence improve readiness of students in facing final exam. Time management training can be implemented during the tutorial class, lecturers can set a suggestion time for students to answer and solve problems. At the beginning, students are allowed to use more time and then subsequently they have to follow the allocation time to complete the task assigned. Lecturers always remind students on time management and encourage students to practice the same during self-learning time. By using Question 2(a) final exam semester 20242 as in Fig. 3 as an example, students are suggested to solve it within 18 minutes. For training purpose, students can use more time e.g. 36 minutes at the first time solving this task but they can practice more times and get it done within 18 minutes or they can try another set of similar question and get the task completed in shorter time. By repetitive training, students will be better prepared and achieve better scores for CO2-PO2 in Solid Mechanic course.

4.0 CONCLUSION

The attainment of CO-PO for Solid Mechanics course in UiTM Johor Pasir Gudang was analysed. It is found that achievement of CO2-PO2 in the final exam assessment was consistently below passing rate of 50% for all the studied semesters, indicating most of the students were unable to develop solutions and analyse problems related to beam questions (Topic 2) in the final exam. Detail investigation on the syllabus content under Topic 2 was carried out and a case study has been conducted to find out why students have failed CO2-PO2 in the final exam. Key findings from the case study has revealed that complexity of the Topic 2 contents, lack of understandings about the topic, low readiness or preparation for final exam and time management in solving final exam questions are the weaknesses of students in scoring good marks in the final exam.

In order to help students in gaining better understanding on Topic 2 (beam), some strategies on the effective teaching and learning such as active learning, collaborative learning, software tool, practical hands-on, co-teaching approach and interactive mobile apps were discussed and suggested to be implemented in the faculty. However, some of the suggestions are not feasible to be implemented due to limited resources and the policy of the university. To improve the attainment of CO2-PO2 for Solid Mechanics, strategy on well preparation for final exam is crucial. Other than putting hard works on several attempts in solving past final exam questions, students need to undergo time management training to make themselves well-versed with the allocation time to complete each task in the final exam questions. The authors strongly believe that this strategy would definitely boost the confidence of students in scoring better marks in the final exam and hence increase the attainment of CO2-PO2 for Solid Mechanics course.

SUGGESTION FOR FUTURE RESEARCH

In order to confirm the findings of current research, quantitative survey and interview of students can be conducted in future. This research has its limitation. It is commonly well noted that the format of assessment affects students' performance in CO-PO as well as the course grade. But this is out of the scope of this study, because to the authors best knowledge, change on format of assessment required tedious procedures and stages of approval from university to the faculty. Provided change of format of assessment is permitted, future research will consider the effect of format of assessment on the attainment of CO-PO for Solid Mechanics.

CO-AUTHOR CONTRIBUTION

The authors affirmed that there is no conflict of interest in this article. Author1 carried out the planning and write-up of the manuscript. Author 2 and author 3 analyse data and provided ideas of the overall study. Author 4 contributed in review and formatting the manuscript.

ACKNOWLEDGEMENTS

The authors would like to thank the management team of the School of Civil Engineering, College of Engineering, UiTM Johor Pasir Gudang for permission of accessing i-RAS faculty.

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