Forensic Investigation on The High Failure Rate of Civil Engineering Solid Mechanics Course

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Abstract: The attainment of program outcomes for Solid Mechanic course offered to the Diploma in Civil Engineering students is evaluated. It was found that most of the students were incapable to demonstrate graduate attributes which applying knowledge of mathematics, natural science and engineering fundamentals and the ability to analyse engineering problems. Therefore, this study investigates the impact of physics and maths scores on the students' performance of solid mechanics. Analysis of the previous results in physics and maths shows that there is a clear link between students' fundamentals knowledge and the understanding of solid mechanics. Meanwhile, this study also aims to find out the root causes that led to the high failure rate of solid mechanics. A quantitative method was employed and a total of 180 students responded to the survey. Results of survey indicate that most of the students perceived that they had limited time to gain deep understanding of the course and they could not visualise the complex problems in solid mechanics. Majority of the students admitted that they did not manage to solve all questions during their final exam, and they were indeed not well prepared for it. Hence, the problem of high failure rate is feasible to be solved provided both lecturers and students making efforts in striving the success of this course.

Keywords: Solid mechanics, Program outcomes, Failure rate, Problem solving, Applying knowledge

1. Introduction

Solid mechanics is known as mechanics of materials which is considered as one of the fundamental core subjects in engineering fields such as civil, mechanical, aerospace and material science. It covers the studies about the behaviour of solid materials under external forces or subjected to temperature change. Specifically, in civil engineering, solid mechanics enable engineers to determine deformations, forces, stresses, strain in basic structural elements prior analysis and design of the infrastructures and buildings. Teaching and learning of this course could be challenging for both students (Kim et al., 2007) and lecturers (Goldfinch, 2008). Generally, this subject is offered in the first year or second year of civil engineering degree or diploma program in Malaysia.

In Malaysia (Kadir et al., 2020), the professional body for accreditation the engineering technician programs is the Engineering Technology Accreditation Council (ETAC), Board of Engineers Malaysia (BEM). Malaysian Qualifications Agency (MQA) was established to monitor and oversee the quality assurance practices and accreditation of national higher education in Malaysia (Rahimullah et al., 2020). 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, 2019). In other words, accreditation is important to produce good quality of future engineers with high attributes that can solve problems ethically and reducing risks in any solutions responsibly (Isa et al., 2019). According to Sankaran & Mohanty (2018), an engineering graduate must acquire graduate attributes which describe expected knowledge, skills, abilities and competency during his or her engineering education.

There are twelve graduate attributes or program outcomes (PO) addressed by the ETAC Malaysia including knowledge, problem analysis, design of solutions, investigation, modern tool usage; the engineer and society, environment and sustainability, ethics, individual and teamwork, communications, project management and finance and life-long learning. The course of solid mechanic is often relevant to the program outcomes emphasis knowledge and problem analysis. These program outcomes require cognitive style by an individual to process data, thought, remember, and solve problems consistently and long-lasting (Adnan, 2021). Therefore, measurement or assessment of these program outcomes can be conducted through assignments, quizzes, tests and final exams. One of the aims in this study is to investigate the attainment of POs through the final scores of students in solid mechanics course under the study program of Diploma in Civil Engineering, Universiti Teknologi MARA (UiTM) Malaysia.

Solid mechanics (ECS226) is a 3.0 credit hours course and it is one of the cores and fundamental subject for the program of Diploma in Civil Engineering, UiTM. Students are compulsory to take this course during their second semester because it is a prerequisite for other structural course such as structural analysis in forth semester as well as link to the structural design course during fifth semester. Therefore, ECS226 is very crucial for the student to pass in one sitting.

This course was first commenced in semester March-July 2018. Table 1 shows the percentage of failure percentage for the three consecutive semesters. Apparently, the failure rate was extremely high (65%) for the early semester. It was tremendously improved in the following semester (Sep 2018-Jan 2019) and then rise again in the later semester (Mar 2019-Jul 2019). The failure rate of this course is gaining attentions at faculty and university level. Thus, lectures or instructors aim to find out the roof causes that led to the poor students' performance through this study. The main objectives of this study are (1) to examine the impact of the scores of physics and maths in previous semester on to the current scores of solid mechanics and (2) to find out the root causes that led to the high failure rate of solid mechanics.

Table 1. Failure rate of ECS226

Semester	Number of students	Percentage of failure (%)
Mar 2018 - Jul 2018	240	65.0
Sep 2018 - Jan 2019	173	14.0
Mar 2019 - Jul 2019	288	37.0

2. Literature Review

Solid mechanics is sometimes referred as mechanic of materials, a basic engineering subject concerned with the strength and physical performance of structures. Research in solid mechanics always emphasizes comprehensive understanding and well-formulated analyses of mechanical phenomena occurring in engineering systems (Carroll,1985). Solid mechanics is considered one of the most difficult introductory courses in undergraduate education in civil engineering (Wang & Wang, 2019). The course outcomes (CO) are generally focus on students' ability to apply basic understanding of stresses and strains in solid body, beams, shafts and columns; and develop solutions for problems related to statically

determinate beam. The associated program outcomes (PO) commonly relate to apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization to wide practical procedures and practices; and identify and analyse well-defined engineering problems reaching substantiated conclusions using codified methods of analysis specific to their field of activity.

Teaching and assessment tools are deemed to be crucial to improve the overall performance of solid mechanics as demonstrated in previous study (Echempati, 2007), some in-class activities such as tutorial provided some what just in time learning experience for many students while carefully designed homework, the competency examination, mini-projects, student presentations, and the midterm and final examinations serve as other tools for assessing the students' learning. To boost students' enthusiasm in learning solid mechanics, some active learning and engagement tools such as web-based learning modules (Sandhu et al., 2002), eBook (Gramoll, 2007) and flip classroom (Ryan, & Kirn, 2015) have been developed as additional supporting tools beside classroom lectures. Rais-Rohani & Walters (2014) have redesign mechanics course by using Emporium model, in which students study the material outside of class via asynchronous modes (online delivery of the content and instructional videos) and students have to do all the other activities such as assignment and tests either individually or in groups inside the classroom. However, teaching approach employed in current course is still a face-to-face lecture-based, with the total four contact hours every week.

Solid mechanics at introductory level generally covers the topics of one-dimensional and two-dimensional linear stress and strain systems; bending stresses, deflection and influence lines of statically determinate beams; torsion of circular shafts and elastic buckling of columns. In this study, all these contents have to be taught within 14 weeks through lectures and tutorials. For assessment, 40% of the total marks allocated for continuous assessment which consists of one test (30%) and one assignment (10%). The remaining 60% is from the final exam. The CO and PO are equally distributed to each of the measurement. Both POs are recognised as cognitive domain which are direct method of assessment. The well-established Bloom's taxonomy is commonly used to measure the different cognitive level that students obtain in engineering topics (Dymond, 2019). Thus, for this course, Bloom's taxonomy level 1-2 (knowledge), level 3-4 (application) and level 5-6 (synthesis) at proportion 3:6:1 were employed in the setting of test and final exam questions.

3. Methodology

Results of solid mechanics at the past three semesters were first analysed in terms of final grade marks as well as the attainment of PO. In order to investigate the effect of their fundamentals (science and maths) knowledge on to the performance of ECS226, two courses known as Fundamental of Physics (PHY145) and Calculus 1 (MAT183) were chosen to establish the relationship. These courses were taken by EC110 students in the semester 1 during their candidature, specifically PHY145 is the prerequisite for student prior register the subject of ECS226. In other words, those students who have taken the subject of PHY145 and MAT183 (with the condition of passing PHY145) in the semester 1 are eligible taking the subject of ECS226 in the following semester. Results of EC110 students in ECS226, PHY145 and MAT183 were analysed, the average (mean) final grade marks were employed to elucidate the link between fundamental science and maths and solid mechanics. All the results of ECS226, PHY145 and MAT183 were obtained from the Academic Affairs Office of UiTM.

Second part of this study adopted a quantitative approach, a survey form was distributed to those EC110 students who have taken ECS226. The respondents were all in their Semester 3, Semester 4 and Semester 5 during survey took place. This survey was conducted in the academic year 2019 (October), it covered a sample size of 180 students. The questionnaire consisted of three sections (A and B) in which section A was about respondent's background and Section B seeking for the factors affecting the score of ECS226. A five Likert scale was utilised in the section B which 1 – Strongly Disagree; 2- Disagree; 3- Neutral; 4- Agree; 5- Strongly Agree. In section B, factors affecting the score of ECS226 can be divided into the nature of the course, teaching materials and methods, students' attitude in studying this course and learning facilities.

The reliability or internal consistency of the questionnaire was verified by using Cronbach's alpha (α). The values of α for Section B and C were 0.84 and 0.79, respectively. According to George

and Mallery (2003), $\alpha > 0.8$ can be yielded as good while $\alpha > 0.7$ can be regarded as acceptable. Therefore, the internal consistency of the questionnaire in this study has been confirmed.

4. Results And Discussion

4.1 Attainment of PO and Average Mark Scores for ECS226

Assessment of ECS226 comprises of 10% of assignment, 30% of test and 60% of final exam in which PO1 and PO2 were in their equal weightage of the full marks. Table 2 indicates the attainment of PO for students in the past three semesters. At a glance, students scored the assignment with the average of 86.3% and 87% in PO1 and PO2, respectively. For both test and final exam, students performed better in PO1 if compared with PO2. This phenomenon was repeating in every semester, demonstrated the consistency of students' performance in PO1 and PO2 for this course.

Table 2. Attainment of PO based on assignment, test and final exam

Semester	Number of student	Assignment (100%)		Test (100%)		Final exam (100%)		Attainment of PO (100%)	
		PO1	PO2	PO1	PO2	PO1	PO2	PO1	PO2
Mar 2018 - Jul 2018	240	92.0	92.0	50.0	49.0	45.0	36.0	51.2	45.5
Sep 2018 - Jan 2019	173	81.0	87.0	59.0	51.0	60.0	50.0	61.8	54.0
Mar 2019 - Jul 2019	288	86.0	82.0	57.0	43.0	50.0	32.0	55.7	40.3
Average		86.3	87.0	55.3	47.7	51.7	39.3	56.2	46.6

Overall, attainment of PO1 and PO2 for EC110 students in this course is considered as average and below average. PO1 is about applying knowledge of mathematics, natural science and engineering fundamentals while PO2 is the ability to analyse engineering problems. Thus, the competency of students in applying mathematics and science knowledge in solid mechanics become the concern that could affect the scores of ECS226. Table 3 shows the average marks for ECS226, PHY145 and MAT183. It is worthy to noted that the same batch of students have taken PHY145 and MAT183 prior taken ECS226 although some students might need to repeat PHY145 and MAT183. This can be explained in the number of students in which the total amount of students registered in ECS226 (in their second semester) was slightly less than the total amount of students registered in PHY145 and MAT183 (in their first semester). On the other hand, the intake for the cohort Mar 2018 was significantly reduce. There were 24 and 34 students enrolled and completed the final exam for their first semester PHY145 and MAT 183, respectively. However, due to the great number of repeaters from previous semester, number of students registered the subject ECS226 in semester Sep 2018 was 173 as shown in Table 3. The students' performance in this semester was improved due to the number of repeaters, the average mark score is 59.7 (Table 3) and the percentage of failure is 14% (refer Table 1).

Table 3. Average mark scores for ECS226, PHY145 and MAT183

Semester	Average Marks (%)		
	ECS226	PHY145	MAT183
Sep 2017 - Jan 2018	-	64.1 (247)	69.4 (256)
Mar 2018 - Jul 2018	39.1 (240)	59.8 (24)	57.4 (34)
Sep 2018 - Jan 2019	59.7 (173)	63.2 (298)	50.3 (299)
Mar 2019 - Jul 2019	48.1 (288)	-	-
Mean	49.0	62.3	59.0

Note: number in ( ) refers to number of students

Result indicates that the students' performance in PHY145 and MAT183 directly linked to their score of ECS226 in the consecutive semesters. Therefore, one of the major causes that led to the poor performance of ECS226 can be confirmed as the lack of ability to apply basic science (physics) and maths knowledge into the problem analysis.

4.2 Outcomes of Questionnaire

A total of 180 respondents provided feedbacks and the outcomes of the survey can be analysed in two sections.

4.2.1 Section A

All respondents were in their age between 19 to 20 years old, 61% were female and the rest were male. Majority of respondents (59%) passed this course for their first time taken, 39% have taken for second time and merely 2% completed this course at their third time. Fig. 1 shows the grade scores of ECS226 among respondents. Majority of the respondents i.e. 44% obtained grade C+/C, followed by 33% scored B+/B/B- and roughly 8-9% of respondents scored the highest grade and the lowest grade of ECS226. It agrees well with average mark scores as shown in Table 3 achieved by students throughout three semesters.

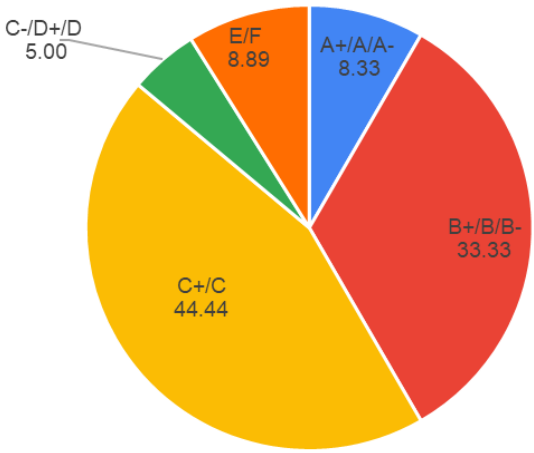

Fig. 1 Respondents' grade score in ECS226

4.2.2 Section B

Section B of the survey investigated the perception of students towards the factors affecting their performance of ECS226. Table 4 shows the mean rate and the rank for the 20 items in the questionnaire. Apparently, students believed the most relevant factor that resulted in poor performance is the limited time for deep understanding of solid mechanics throughout their 14 weeks lectures and tutorials (with the mean rate is 3.62). The program outcomes and course outcomes have suggested that cognitive domain that required students' understanding at the first place, then the ability of applying theory and concept in analysing the problems of solid mechanics. This problem is always associated with the packed syllabus, in which too many contents need to be covered. However, result from questionnaire indicates that mean rate for this item is 3.15 which ranked number 9 out of total. Students also responded that they had difficulties to visualise the problem solving in this course because they are often complex. The mean rate is 3.44, ranked number 3 among all. It is understandable that students were fresh and never exposed to civil engineering applications before, thus they must imagine how the

real solid structures being connected from the free body diagram which they see during the class. However, students will improve from time to time if they are exposed to the practical applications or through some lab experiments which can simulate the behaviours of a solid body under different actions.

Table 4. Student perception on factors affecting performances of ECS226

No.	Item	Mean Rate	Rank
1.	The syllabus is packed with too much content.	3.15	9
2.	Students had little time to acquire a deep understanding of this course.	3.62	1
3.	I lacked competent in applying the knowledge of mathematics and science in this course.	3.01	13
4.	I had difficulties to visualise the problem solving in this course because they are often complex.	3.44	3
5.	Final exam questions were too lengthy and tedious.	3.45	2
6.	I did not manage to solve all the final exam questions within the given time.	3.43	4
7.	Lecture notes/materials weren't helpful for my understanding about this course.	2.70	15
8	Teaching method adopted by my lecturer was not able to gain my focus during lecture/tutorial.	3.04	12
9	Lecturer was not approachable, ever ready to provide academic guidance and accessible for discussion.	2.56	18
10	Most of the time, i lost concentration during lecture/tutorial.	3.14	10
11	I lacked reading habit and reading plan for this course.	3.18	7
12	I was fear to this course and i had no confidence throughout the semester.	3.30	6
13	I was lazy to put more efforts for this course.	2.68	17
14	I was not well-prepared for the final exam.	3.35	5
15	I seldom took initiative to try other problem solving on top of the exercises given by lecturer.	3.17	8
16	I felt reluctant to ask question or seek help if I don't understand or cannot solve the problems.	3.06	11
17	I had no buddies to study together for this course.	2.40	19
18	I had no interest to study this course.	2.19	20
19	I think the equipment space for teaching and learning was not conducive.	2.69	16
20	The method of assessments was not appropriate to address students' performance in this course.	2.98	14

The top second and forth key factors that contributed to the poor performance of ECS226 were about lengthy final exam questions and they did not complete the solutions for all final exam questions. The mean rates of the level of agreement are 3.45 and 3.43, respectively. Due to the cognitive domain based-assessment, final exam was playing the major role in contributing the total mark of ECS226. Therefore, students have tendency to fail this course if the score of his or her final exam is lesser than 50% (out of 100%). This can be evidenced from Table 2 that the PO attainment in the section of final exam. Indeed, if investigate further the item 6 (I did not manage to solve all the final exam questions within the given time) and 14 (I was not well-prepared for the final exam), it was not surprisingly that these are inter-related as shown in Fig. 2. For these items, 34% and 39% of the respondents have chosen to be neutral (neither agree nor disagree), probably due to the poor memory of their past experiences. However, nearly half of the respondents (49%) have admitted that they did not manage to solve all the final exam questions within the given time (Fig. 2). Also, nearly the same amount of the respondents (44%) agreed that they were not well prepared for the final exam. On the other side, around 17-18% respondents declined these 2 statements.

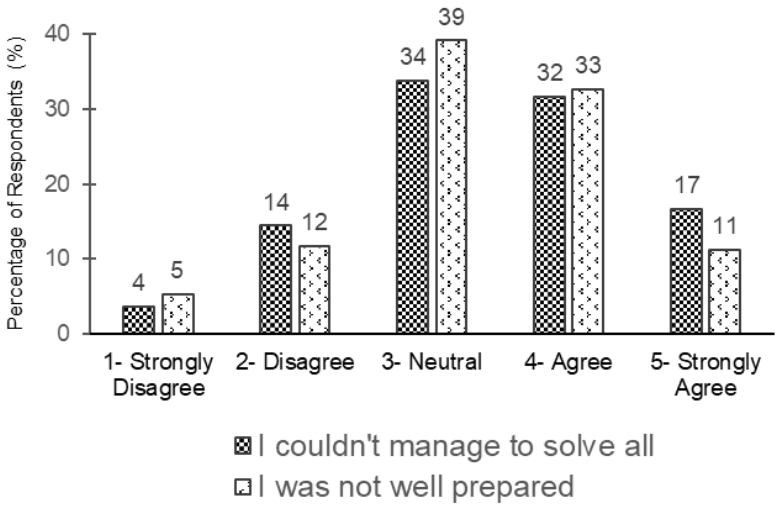

Fig. 2 Responses for item 4 and 6

The least relevant factors that affecting the performance of ECS226 are recognised as item 9, 17 and 18 (Table 4). Notably, nearly 50% of the respondents were in the disagreement and strong disagreement to the statements about the lecturer was not approachable, I had no buddies to study, and I had no interest to study (Table 5).

Table 5. Respondents for item 9, 17 and 18

Likert scale	Percentage of respondents (%)		
	Item 9	Item 17	Item 18
	Lecturer was not approachable	I had no buddies to study	I had no interest to study
1- Strongly Disagree	14	18	27
2- Disagree	35	35	37
3- Neutral	36	37	27
4- Agree	11	9	9
5- Strongly agree	4	1	1
Total	100	100	100

4.3 Discussion

Analysis of questionare responses indicated that main root cause that resulted in poor performance of solid mechanics is the limited time for deep understanding of its course content and followed by final exam questions were too lengthy and tedious. Students claimed limited time for deep understanding this subject, possibly attribute to inapprioate syllabus design with the contact hours. Previous study (Echempati,2007) also pointed out that conventional set up in which students keep in touch with the instructor outside of the classroom in the form of office hours, and with the subject matter (either individually or with a group) in the form of reading assignments, homework, and preparation for

the examinations is not enough to prepare them well in order to achieve a satisfactory overall performance in solid mechanics. Therefore, some innovative learning activities need to be implemented to enhance understanding of this course.

Students had perception that final exam questions were too lengthy and tedious, possibly due to conceptual misunderstanding (Liu & Fang, 2016) among students. In science, technology, engineering, and mathematics (STEM) disciplines, misconception is regarded as the key reason leads to poor academic performance (Bransford et al., 2000). According to Liu & Fang (2016), misconceptions of students in engineering mechanics likely inherited from his or her minsconception in physics. Therefore, poor performance of solid mechanics could be link to the average performance in physics as shown in this study.

5. Conclusion

Evaluation on the students' performance in solid mechanics course was carried out through analysis of the scores in the past three semesters. The attainment of program outcomes for this course is unsatisfactory in which program outcome 2 (PO2) did not meet the minimum requirement of 50%. Results of study have confirmed that the poor performance of students in solving solid mechanics problems are likely related to their average performance in fundamentals of science (physics) and maths (average mark scores of 62.3% and 59% in physics and maths, respectively).

Statistics of the failure rate indicate that students able to pass solid mechanic when they are given second chance, probably due to the learning experience and most importantly, gaining enough time for deep understanding of this subject. Coincidentally, the questionnaire responses provide a consistent fact that most of the students agreed that due to the limited time to acquire a deep understanding of this course, they could not perform well in solid mechanics. Results of survey also highlighted some important factors that contributed to the high failure rate such as lengthy and tedious final exam questions, students have difficulty to visualize the problem solving in this course because they are often complex and students did not manage to solve all the final exam questions within the given time because they were not well-prepared for the final exam.

Another important finding from the questionnaire is that students perceived that they have interest to learn solid mechanics, lecturers were approacheable and they had buddies to study with. Students awared of their responsibilities and they just need to be more positive and aggressive when they are difficulty in understanding the course. Therefore, the problem of high failure rate is feasible to be solved provided both lecturers and students making efforts in striving the success of this course. Motivation by lecturer is undoubtedly a major drive to enhance students' learning (Halif et al., 2020) and it would be essential to improve engagement of students in classroom.

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7. References

Adnan, M. (2021). Metacognition of Junior High School Students in Mathematics Problem Solving Based on Cognitive Style. *Asian Journal of University Education (AJUE), 17*(1), 134-144.

Bransford, J., Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn: Brain, mind, experience, and school*. National Academies Press.

Carroll, M. M. (1985). Foundations of Solid Mechanics. *Applied Mechanics Reviews*, *38*(10), 1301.

Chen, S. J., & Chen, S. M. (2007). Fuzzy risk analysis based on the ranking of generalized trapezoidal fuzzy numbers. *Applied Intelligence, 26*(1), 1-11.

Dymond, B.Z., Swenty, M. and Carroll, J.C. (2019). Comparing Exam Performance in a Reinforced Concrete Design Course with Bloom's Taxonomy Levels'. *Journal of Civil Engineering Education*, *146*(1), 04019001.

Echempati, R. (2007). Learning Experiences of Using Teaching and Assessment Tools for Solid Mechanics Course.

George, D. and Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference*. *4th ed.*, Boston, Allyn & Bacon.

Goldfinch, T., Carew, A.L., Gardner, A., Henderson, A., McCarthy, T.J. and Thomas, G. (2008). Cross-institutional comparison of mechanics examinations: A guide for the curious. *Proceedings of the 2008 AaeE Conference*, Yeppoon, 1-8.

Gramoll, K. (2007, June). A web-based electronic book (ebook) for solid mechanics. In *Proc. ASEE Annual Conf.(Mech. Div. Best Pres. Award), Honolulu, HI, USA*.

Halif, M. M., Hassan, N., Sumardi, N. A., Omar, A. S., Ali, S., Aziz, R. A., ... & Salleh, N. F. (2020). Moderating Effects of Student Motivation on the Relationship between Learning Styles and Student Engagement. *Asian Journal of University Education*, *16*(2), 94-103.

Isa, C.M.M., Joseph, E.O., Saman, H.M., Jan, J., Tahir, W. and Mukri, M. (2019). Attainment of Program Outcomes under Psychomotor Domain for Civil Engineering Undergraduate Students. *Journal of Academic Research in Business and Social Sciences, 9*(13), 107-122.

Kim, K.J., Rezaei, A., Shih, A., Jawaharlal, M. and Shelton, M. (2007). Development of Online Hands-On Experiments for Hybrid Vector Statics Courses. 12.538.1-8.

Liu, G., & Fang, N. (2016). Student misconceptions about force and acceleration in physics and engineering mechanics education. *International Journal of Engineering Education*, *32*(1), 19-29.

Qadir, J., Shafi, A., Al-Fuqaha, A., Taha, A. M., Yau, K. A., Ponciano, J., … Tan, B. L. (2020). Outcome-Based Engineering Education: A Global Report of International OBE Accreditation and Assessment Practices. Doi.org/10.35542/osf.io/rde62

Rahimullah, B. N. S., Mansor, W., Latip, M. F. A., Mohamad, H., & Abdullah, S. A. C. (2020). Analysis of Graduates Performance Based on Programme Educational Objective Assessment for an Electrical Engineering Degree. *Asian Journal of University Education*, *16*(3), 303-309.

Rais-Rohani, M., & Walters, A. (2014). Preliminary Assessment of the Emporium Model in a Redesigned Engineering Mechanics Course. *Advances in Engineering Education*, *4*(1), n1.

Ryan, K., & Kirn, A. (2015). Active Learning and Engagement in Mechanics of Solids.

Sandhu, J. S., Bamberg, E., Hong, J. W., & Boyce, M. C. (2002). Active engagement pedagogy for an introductory solid mechanics course. *age*, *7*, 1.

Sankaran, M. and Mohanty, S. (2018). Student perception on achieved graduate attributes and learning experiences: a study on undergraduate engineering students of India. *International Journal of Continuing Engineering Education and Life-Long Learning*, *28*(1), 77-98.

Sern, L. C. and Salleh, K. M. (2015). Comparison of Example-Based Learning and Problem-Based Learning in Engineering Domain. *Universal Journal of Educational Research*, *3*(1), 39-45.

Standard of Engineering Technician Education Programme Accreditation (2019) ETAC, Malaysia.

Steif, P.S. and Naples, L.M (2003). Design and Evaluation of Problem Solving Courseware Modules for Mechanics of Materials. *Journal of Engineering Education*, *92*(3), 239-247.

Van Gog, T., Paas, F., and Van Merriënboer, J.J.G. (2008). Effects of studying sequences of process-oriented and product-oriented worked-examples on troubleshooting transfer efficiency. *Learning and Instruction*. *18*(3), 211-222.

Wang, H., & Wang, F. (2019). Innovation in Teaching Mechanics of Materials in Civil Engineering-Taking Classroom Teaching as an Example. In *2019 3rd International Conference on Education, Management Science and Economics (ICEMSE 2019)*. Atlantis Press.