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LEARNING APPROACH IN ENGINEERING DYNAMICS COURSE OF MECHATRONIC ENGINEERING TECHNOLOGY PROGRAMME IN THEORETICAL AND EXPERIMENTAL LEARNING SCENARIOS

Hafizan Hashim[1*], Noor Azean Anis Binti Abd Aziz[2] & Hanita Hashim[3]

[1]School of Mechanical Engineering, College of Engineering
Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[2]Faculty of Medicine, Universiti Teknologi MARA
UiTM Sungai Buloh Campus, 47000 Sungai Buloh, Selangor, Malaysia
[3]Faculty of Engineering and Life Sciences, Science and Biotechnology Cluster
Universiti Selangor (UNISEL), Jln Timur Tambahan
45600 Bestari Jaya, Selangor, Malaysia
(Corresponding author: hafizandes@gmail.com)

Abstract

How crucial are engineering mechanics courses for Mechatronic Engineering Technology Programme (METP)? Engineering dynamics is one of the mechanical fundamental courses taught in METP, UiTM Shah Alam, Malaysia. Teaching engineering mechanics courses can be challenging for several reasons: abstract concepts, math-intensive, and diverse backgrounds. Even though deep learning is mostly desirable in higher education, the learning scenarios can sometimes inspire different learning styles. The purpose of this study is to examine the learning approach adopted by mechatronic engineering technology students during engineering dynamics course in two learning situations: theoretical and experimental learning. Samples were recruited from the first cohort of METP students in UiTM. Online questionnaires that consist of revised R-SPQ-2F were distributed after completion of course assessment. Students were clustered into three types of learning approaches in the two scenarios: deep learning, mixed learning, and surface learning. Results showed that students from different backgrounds adopted different learning approaches in different scenarios. Factors such as previous institution, grade, and theoretical exposures play major roles in classifying students' learning approaches. The study findings can help improve students' learning approaches by specifically manipulating changes in the learning environment.

Keywords: Deep learning; engineering technology students; experimental learning; R-SPQ-2F; theoretical learning

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Abstrak

Betapa pentingkah kursus-kursus mekanik kejuruteraan di dalam Program Teknologi Kejuruteraan Mekatronik (METP)? Dinamik kejuruteraan adalah salah satu kursus asas mekanikal yang diajar dalam METP, UiTM Shah Alam, Malaysia. Penyampaian kursus kejuruteraan mekanikal menjadi cabaran oleh beberapa sebab seperti; pemahaman konsep, asas matematik yang kukuh, dan kepelbagaian later belakang pelajar. Walaupun pembelajaran mendalam adalah pilihan yang dikehendaki dalam pendidikan tinggi, situasi pembelajaran boleh menggalakkan gaya pembelajaran yang berbeza. Tujuan kajian ini adalah untuk mengkaji pendekatan pembelajaran yang diambil oleh pelajar teknologi kejuruteraan mekatronik semasa kursus dinamik mekanikal dalam dua situasi pembelajaran: kelas teori dan makmal. Sampel diambil daripada kohort pertama pelajar METP di UiTM. Kaji selidik dalam talian yang terdiri daripada R-SPQ-2F versi terkini diedarkan selepas penilaian kursus selesai. Pelajar dikumpulkan kepada tiga jenis pendekatan pembelajaran: pembelajaran mendalam, pembelajaran campuran, dan pembelajaran permukaan. Keputusan menunjukkan bahawa pelajar daripada latar belakang yang berbeza menggunakan pendekatan pembelajaran yang berbeza dalam situasi yang berbeza. Faktor seperti institusi sebelumnya, gred, dan pendedahan teori memainkan peranan utama dalam mengklasifikasi pendekatan pembelajaran pelajar. Hasil kajian mampu membantu memperbaiki pendekatan pembelajaran pelajar dengan memanipulasi perubahan persekitaran pembelajaran secara spesifik.
Kata kunci: Pembelajaran mendalam; pelajar teknologi kejuruteraan; pembelajaran makmal, pembelajaran mendalam; R-SPQ-2F; pembelajaran teori

1.0 INTRODUCTION

The 17 Sustainable Development Goals (SDGs) is the 2030 Agenda adopted by United Nations that provides a blueprint for prosperous and peaceful planet and everything that lives on it, now and into the future. Nowadays, development and adoption of new science and technology that is sustainable, affordable, and safe, has become a priority in many countries. Culturizing science and technology into society could expedite the vision with the support from government and other agencies. To develop and boost healthy scientific community, Malaysia needs to increase interest among students to further study in STEM as well as encourages interaction among sub-communities in scientific fields at higher level. Higher participation rates in STEM related higher education can be established by widening overall participation including those from polytechnics and vocational institutes.

Today, graduates from vocational and polytechnics in Malaysia can further their study to

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degree level in engineering technology programme offered in many public universities and equivalent private institutions. Courses related to the Fourth Industrial Revolution (IR4.0) such as mechatronics, computer science, and electronics have shown an increase in the number of student engagements. The surging wave of IR4.0 is expected to elevate our living standards and change our perception of valuing things. Therefore, reform in undergraduate engineering education is important to segregate a more scientific, theoretical approach and a more applied engineering approach (Hariharasudan & Kot, 2018). On top of that, the country is still facing problems such as low student engagement in STEM (Fatin Aliah Phang et al. 2012), lack of enthusiasm among students (Ong, 2022), teacher's attitude (Ling Chia et al. 2018), various learning approaches, and lack of information from authorities (Nur Farhana Ramli & Othman Talib, 2017). Thus, reengineering the education system for better learning quality is still a challenge among engineering college educators, administrators, as well as policy makers in the government.

Education Policy in Malaysia emphasizes the importance of STEM in supporting the development of science and technology in the country. The Education Ministry's 2020 Annual Report showed that only 47.18 per cent students had chosen STEM for their higher education route. According to Ministry of Science, Technology, and Innovation, Malaysia (MOSTI), for consistent growth momentum and adequate supply of manpower, Malaysia needs to increase the percentage of students in STEM to at least 60 per cent (Bernama, 2021). Universiti Teknologi MARA (UiTM) is one of the public universities in Malaysia that offers STEM-related courses. Mechatronic engineering technology program is the first engineering technology program offered by College of Engineering, UiTM. The first batch of candidates had registered with college in September 2021 and currently pursuing their third semester. With some physical embodiments of mechanical engineering, students in this course are required to complete some mechanical core courses including Engineering Dynamics. They came from various educational backgrounds including some from matriculation, polytechnic, vocational college, and foundation centre (*ASASI*).

In general, engineering technology courses contain more practical compared to engineering. This study focuses on the learning approaches adopted by mechatronic engineering technology students in engineering dynamics course in UiTM. The study framework was developed to investigate type and state of learning approach for the students in the context of two learning scenarios, theoretical, and experimental learning. Practical work is carried out during engineering dynamics course through experimental approach, accounts for about 21% of their total course hours. An online questionnaire consists of revised R-SPQ-2F were distributed after completion of course assessment. Students were clustered into three

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groups in the two scenarios: deep learning, mixed learning, and surface learning. Learning quality among students could be improved through different learning attributes and scenarios. A deep learner is motivated to discover the meaning of a particular subject and the surface learner only interested with the discourse. Deep learning approach is popular among college student because it focuses on the meaning of what is learned and how to organize information (Takase & Yoshida, 2021; Tannoubi et al. 2022). Figure 1 shows comparison of magnitude estimates for surface, mixed, and deep learning approach. This study provides a picture of the learning approach embraced by mechatronic engineering technology students in learning engineering dynamics in UiTM and to characterize their learning state and improve learning quality.

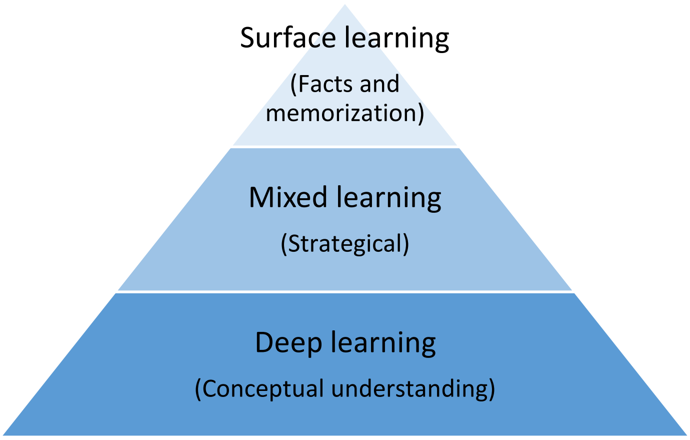

Figure 1. Comparison of magnitude estimates for surface, mixed, and deep learning approach

2.0 METHODOLOGY

2.1 Classification of Learning Approach

Deep learning involves critical analysis of the information being studied for better understanding. Instead, surface learning is a rather passive approach to learning and search for ideas of the study material and content present in a curriculum and nothing more. The Revised Study Process Questionnaire (R-SPQ-2F) developed by Biggs is a tool of reference to measure individual differences in learning approach (Biggs et al. 2001). In this study, the R-SPQ-2F is used to measure variable characteristics and responses. The questionnaire consists of 20 questions divided into four dimensions: deep learning motive (DM) and deep learning strategy (DS), and surface learning motive (SM) and surface learning strategy (SS).

The rating scale questions in R-SPQ-2F contains four answer items, 0 = I never or rarely do this, 1 = I sometimes do this, 2 = I do this about half the time, 3 = I often do this. Each answer carries 0 to 3 points which were later used in the analysis. The Cronbach's Alpha of the four subdimensions in the questionnaire is between 0.6729 and 0.8803 (Biggs et al.

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2001). Cronbach's alpha is a psychometric statistic which is used to estimate reliability or internal consistency of a scale.

The Mechatronic Engineering Technology Students' Learning Experience questionnaire prepared in this study was revised based on R-SPQ-2F. It consists of two parts, the background survey and questionnaire on deep learning according to two scenarios focusing on Engineering Dynamics course. A total of 31 students from mechatronics engineering technology programme, School of Mechanical Engineering, UiTM Shah Alam were involved in the study survey. Since the population size is too small, the entire population were analyzed without any sampling technique. There were 24 male students accounting for 77.42% of the total and 7 female students, accounting for 22.58%, from various background. Table 1 shows overall Cronbach's Alpha for both scenarios were greater than 0.7, thus indicates the requirements of measurement indexes were achieved. Figure 2 shows the flowchart of the overall work conducted.

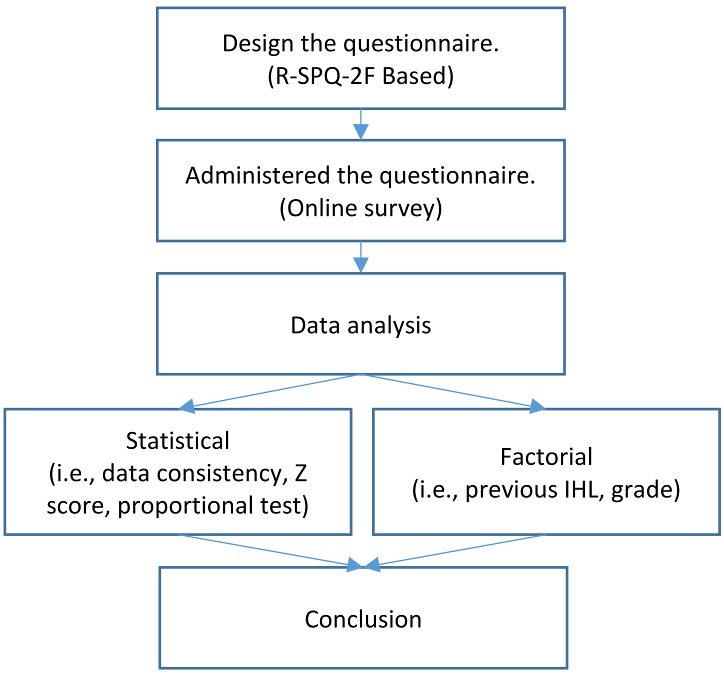

Figure 2. Methodology flowchart

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2.1 Data Collection

Data were collected within a month through online survey since it is more convenient and better responses.

Table 1. The Cronbach's Alpha

Scenario	Dimension	Cronbach's Alpha
Theoretical learning	DM	0.8014
	DS	0.7238
	SM	f0.7211
	SS	0.7633
	Overall	0.8231
Experimental learning	DM	0.7393
	DS	0.8803
	SM	0.7149
	SS	0.6729
	Overall	0.7896

3.0 RESULTS AND DISCUSSION

3.1 Students' Learning Approach in Different Learning Groups

Teaching and learning process may be influenced by learning styles (Mohaffyza et al. 2021). Problems may also arise from insufficient knowledge of the modes of learning which could lead to a detrimental effect on the implementation of the acceptable and successful learning styles among students (Miranda et al. 2021). There is a need for students to identify their learning styles to build and expand their learning skills and experiences (Lwande et al. 2021). Educators can play an active role by encouraging students to identify their learning style and to reposition themselves in the higher education learning environment (Vargas-Hernández & Vargas-González, 2022).

Individual differences in the learning process are normal however it differs significantly when it comes to the objective, level of understanding, and the way of attainment in learning. Comprehending complexity often raise curiosity and interest that leads to adoption of deep processing to understand the true meaning of something, while individual with knowledge accumulation tends to memorize what is learnt through surface processing. There are also individuals who adopt both deep and surface learning depending on instruction and

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assessment requirements (Zhao et al. 2022).

In general, the system implemented in technical and vocational institutions are designed to help students to get a job after graduation. They are taught the necessary knowledge and skills to carry out a specific job or professional activity in the labor market to become a competent worker as well as citizen. During the process, students will involve in technology transition, innovation, and skill growth to form a solid foundation of their technical progress. Nevertheless, understanding the differences in student learning style and learning approach could help institution to design a well-suited curriculum for the students.

This study consists of two learning scenarios which are theoretical learning and experimental learning. Samples were clustered in these two learning scenarios based on R-SPQ-2F questionnaires where DM and DS captured the tendency for deep learning and SM and SS for surface learning. Specific learning motives and strategic preference among students can be determined from each of these engagements. Based on the two scenarios, students were divided into four groups as shown in Figure 3 and Figure 4. The first group of students from both theoretical and experimental studies indicate similar patterns, where their scores were above average for the two dimensions of deep learning motive and strategy. On the other hand, surface learning motive and strategy obtained a below average score. Students in the deep learning cluster seemed to have good reputation, with total number of 12 and 18 students for theoretical and experimental learning scenarios respectively. This accounted for about 39% and 58% of the total students.

Referring to the theoretical learning, the next group which is the mixed learners, scored above average on deep learning motive and surface learning strategy, but below average on deep learning strategy and surface learning motive. These results differ from experimental learning scenario when deep and surface learning motive were above average, but deep learning and surface learning strategy were below average. The group of student accounted for about 16% and 19% from theoretical and experimental learning scenarios respectively.

The third group scores below average on deep motive and strategy, but above average on surface motive and strategy respectively. Most of the time, those practicing surface learning tends to have a lack of fundamental knowledge to understand one material. The group of student accounts for about 45% and 7% of the total students in theoretical and experimental learning scenarios respectively.

3.2 Deep Learners (DL)

Students in this group scored higher for deep approach than surface. In this approach, learners were committed in learning and showed great interest in the subject. Deep approach

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resulted in better adaptation to ‘student self-assessment’ (SSA) (Andrade & Du, 2007) that involves student in grading their own work to ensure student comparability (Nieminen et al., 2021) and may lead to deep and meaningful learning (Mystakidis, 2021). The group of students accounted for 38.71% and 58.06% of the total of two scenarios. This result showed that more than half students preferred a more hands-on and interactive approach in learning since experimental work provides physical experience.

3.3 Surface Learners (SL)

Surface learners scored higher for surface learning than deep learning. They lack real interest in learning, most of them just do it to pass the exam. This type of learner spends minimum time for learning and often avoid discussions and additional works which are not included in the assessment score. They do not accept responsibility for their own learning even though they have more control over their learning. The learners also seem to have involved in active learning during laboratory time because the pedagogy required them to do so. This group also mostly preferred hands-on learning instead of listening to someone else to tell them what they should know. In the two scenarios, the group of students accounted for 45.16% and 22.58% of the total respectively.

3.4 Mixed Learners (ML)

Learners in this group have at least one positive score in both deep and surface learning approach. These students really wanted to seek actual meaning of what they were studying, and this can be seen in both theoretical and experimental scenarios for deep learning. The experimental hands-on has double positive score from deep and surface motive. Even though both were incompatible because theoretically students cannot adopt both at a time, it indicates student perception against experimental work. It is quite paradoxical but in comparison of both theoretical and experimental, students’ preference still can be perceived. These two scenarios accounted for 16.13% and 19.35% of the total students.

Table 2. Percentage of students according to learning types and scenarios

	DL (%)	ML (%)	SL (%)
Analytical	39	16	45
Experimental	58	19	23

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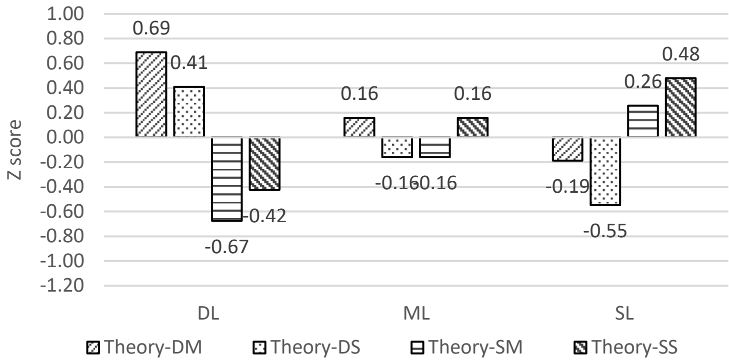

Figure 3. Theoretical scenario: Learning scores according to learning types

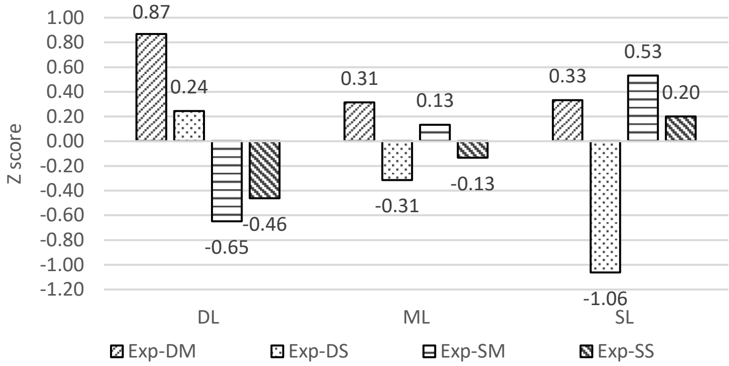

Figure 4. Experimental scenario: Learning scores according to learning types

3.5 Academic Background Differences in Specific Learning Types

Figure 5 and 6 show distribution of learning approach among students in theoretical and experimental clusters with reference to previous institution respectively. Majority students from matriculation (Matric) which was the largest group, adopted deep learning in both clusters. Same goes to students from foundation (Found). However, the second largest group of students from polytechnic institute (Polytech) seemed to prefer surface learning in theoretical cluster and deep learning in experimental cluster. This could possibly be due to the nature of university that emphasized on imparting basic knowledge with a lot of theoretical aspects. The same pattern can be seen for national (VC-N) and private vocational college (VC-P) students. Undoubtedly, students from these two institutions undergo so called experiential learning where in-depth study is combined with practical.

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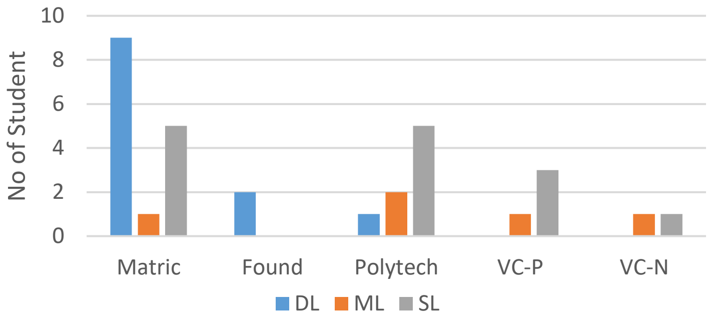

Figure 5. Distribution of learning approach among students in theoretical cluster with reference to previous institution

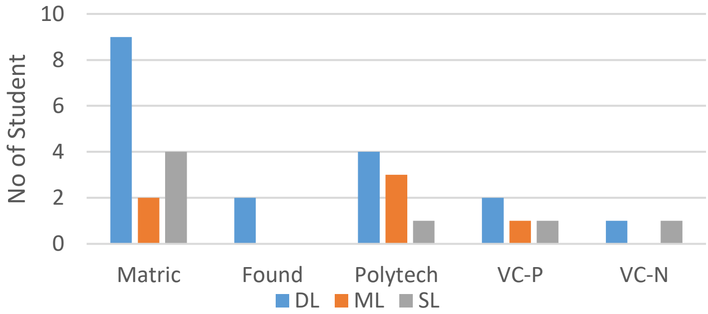

Figure 6. Distribution of learning approach among students in experimental cluster with reference to previous institution

Figure 7 and 8 show distribution of learning approach among students in theoretical and experimental clusters with reference to previous academic major respectively. Previously, these students had majored in five different areas which are Matriculation (Matric), Foundation (Found), Mechatronics (Mechr), Electric-Electronics (EE), and Marine Engineering (Mar). As can be seen, students from matriculation and foundation remained the same for both factors of previous institution because both were considered preparatory level to university. Students from polytechnics and vocational showed similar pattern in both clusters compared to institutional factor as both indicated more interest in experiment approach.

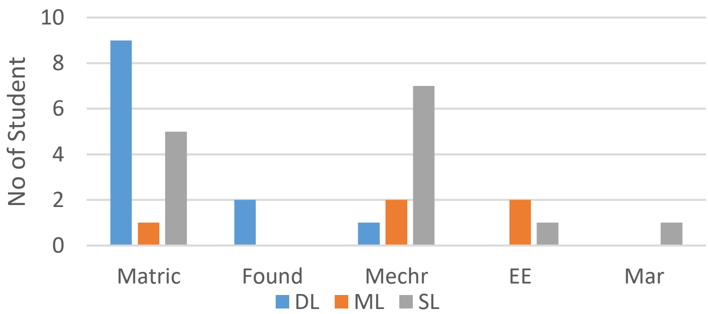

Figure 7: Distribution of learning approach among students in theoretical cluster with reference to previous academic major

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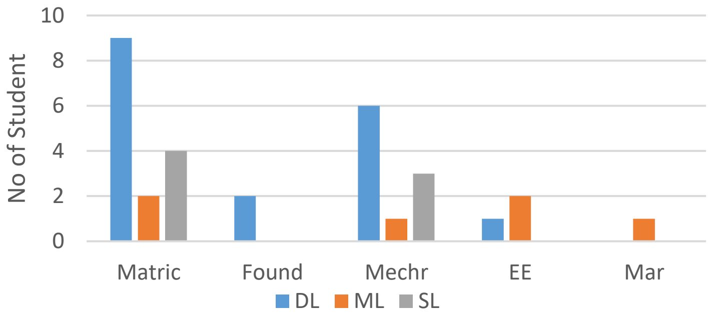

Figure 8. Distribution of learning approach among students in experimental cluster with reference to previous academic major

3.6 Differences in Different Types of Scenarios

Generally, UiTM adopts one-to-many teaching method during theoretical learning session and sometimes combination of one-to-one teaching guidance for experimental learning scenario. Lectures are mainly located in the classroom and big hall, while experimental works are conducted in laboratories as both are two different curriculum systems. The continuous line that represents experiment scenario in Figure 9 significantly deviates upward to the deep learning approach. It indicates that, memory and retelling alone is insufficient to accomplish the tasks. Students, on the hand need to understand the manual operation of equipment and adopt deep learning to explore the 'why' and 'what'. Results show that the majority of the students that accounted for 58.06% applied deep learning approach during experiment and 45.1% applied surface approach in theoretical learning scenario. It seems that students tend to be more choosy to conduct deep learning due to the nature of experiments that require limited time and effort.

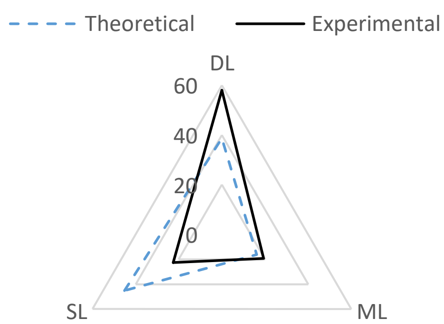

Figure 9. Proportional of different learning approach in different scenarios

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3.7 Grade Differences in Different Learning Types

Figure 10 and 11 show distribution of learning approach among students with reference to academic achievement (CGPA) from previous institution and UiTM. Students with deep learning are mostly from matriculation and foundation. Both also dominate for grade B and above in UiTM semester one, indicating that this group has clearer objectives of learning and intrinsic motives, thus inclined to implement deep learning approach. The proportion of learners in the freshman year of university involved in deep learning increased with increasing grade.

Students from mixed learning group who scored A previously had dispersed to lower grade evenly except one who is from matriculation. Surface learners who were initially normally distributed had declined towards lower grade, and surprisingly this includes student from matriculation as well. Theoretical learning scenario showed that almost half of the students abandon DL but adopted SL approach possibly due to difficulty of theoretical learning that led to lack of interest in learning. In addition, polytechnics and vocational education incorporate work-integrated learning through real-world experiences, in other words, learning by doing.

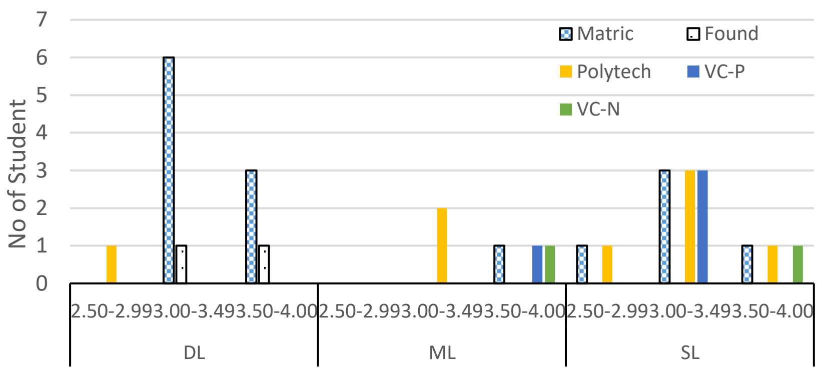

Figure 10. Distribution of learning approach among students with reference to academic achievement (CGPA, previous institution)

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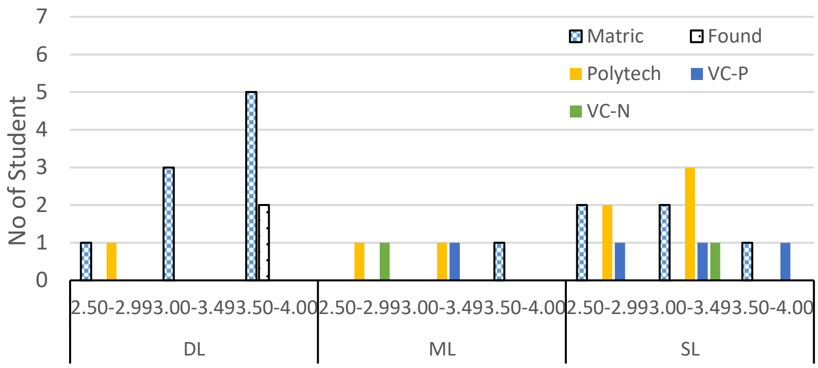

Figure 11. Distribution of learning approach among students with reference to academic achievement (CGPA, UiTM).

4.0 CONCLUSION

The objective of this paper was to examine the learning approach adopted by mechatronic engineering technology students of UiTM, Malaysia, in two different scenarios using Bigg's R-SPQ-2F. We divided students into three learning groups: deep learning, mixed (deep-surface) learning, and surface learning type. Results showed that:

1) Academic background differences affect learning approach. Students from different institution have different proportion of cognitive levels of thinking. Students with higher order thinking skills tended to adopt deep learning approach.

2) Two different dynamics course scenarios have been studied. Students in the program seemed to easily adopt deep learning approach when conducting experiment and it was approximately 20% higher than that of theoretical group.

3) Differences in previous grades led to different learning approach. As can be seen, the only grade that increased significantly in the first year of university was grade B and above for deep learning. Other learning approaches indicated lower number of scores, which was B and above, as compared to previous institution.

There is some limitation in this work which cannot be avoided. The results obtained may not be accurate enough since the number of students involved was small. For better results, large scale samples are required so that the sampling distribution of the sample mean is approximately normal. Furthermore, only two learning scenarios were discussed in this study even though other scenarios exist. Overall, the study reveals some results on the students' approaches to learning engineering dynamics that can be used for improving the learning approach by specifically changing the learning environment. It is suggested that further study is required to better understand the effect of changing the learning approach on students' academic well-being whether useful change is perceived or not.

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