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ORIGINAL ARTICLE

Critical success factors of service learning in tertiary education: Challenge of online learning approach in Ergonomics Product Design Course.

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Abstract: This study intent to investigate critical success factors of implementing online learning approach in ergonomics product design course embedding SULAM Project during COVID-19 pandemic. The first objectives are to interrogate suitable teaching approach implemented for PDET. Next is to assess students' satisfaction with the course in comparison to their grades after SULAM was embedded in SULAM in PBL component, as well as the impact of the pandemic on satisfaction levels. The third aims are to evaluate student perceived and experiences, as well as to discover relevant student recommendations that may be integrated into the next course offering. To achieve the study aims, a systematic literature review was conducted to investigate the current teaching and learning implementation in PDET course. OMR Forms and User Experience Questionnaire (UEQ) were distributed to access students' satisfaction and perceive experiencing in online learning approach. As a results, the course has been identified commonly deploys an inclusive design approach and integrating an interdisciplinary approach. However online learning and team cognition approach has been a significant change during COVID-19 pandemic outbreak. This study extends significantly to the preparation of teaching and assessment techniques for future students, especially in unpredictable conditions such as pandemic and endemic scenarios, when lectures and students confronting various problems.

Keywords: Product Design Engineering Technology (PDET), Human Factors & Ergonomics, SULAM, COVID-19, service learning, online learning

1.0 INTRODUCTION

Product Design Engineering Technology (PDET) contributes the process of designing product that employs engineering techniques and design expertise. When it comes to products, it's frequently taught as a blend of mechanical, electronic, software engineering and industrial design. Human factors and ergonomics (HFE) convey a significant contribution to PDET. Ergonomics/Human Factors Engineering (HFE) is infrequently considered in engineering design, and design techniques don't really effectively demonstrate HFE's utilisation. The challenge of teaching and learning of HFE in PDET

encounter a rapid learning change during COVID-19 pandemic. Consequently, this study describes a cross-sectional study undertaken with PDET students in University Malaysia Perlis, Malaysia, to examine their understanding of HFE and its application in PDET by implementing online approach.

The Malaysian Engineering Technology Accreditation Council (ETAC) of 2020, an engineering education initiative board, have recommended that technology engineering students shall be provided with opportunities to participate in real-world projects to supply them with the skills they will need in the workplace[1]. Since 2019, selected course has been part of the Service-Learning Malaysia- University for Society (SULAM) programme. Since then, the learning and evaluation process has been modified to meet SULAM's requirements. Furthermore, due to the global COVID-19 epidemic, many courses have to adapt its teaching and learning approaches substantially. A survey was conducted to obtain student feedback on the acceptability incorporating online learning approaches in PDET courses in order to verify the applicability of the online approach and SULAM in engineering technology education. As a result, this study was conducted to determine the effectiveness of SULAM deployment and online learning in enhancing PDET teaching and learning by incorporating ergonomics and human factors (HFE).

The first aim is to investigate current teaching and learning approach of implementing service-learning into HFE in PDET course. The second aim is to evaluate students' satisfaction and grades towards the course after SULAM implementation, as well as the consequence of the pandemic on satisfaction scores. The second aim is to present the students' grade with SULAM implementation to identify the effect of the pandemic in the students' grade. The second aim will be analyzed using OMR survey distribution method. Finally, the third objective is to evaluate student perceived and experiences and identifying applicable student suggestions to be embedded into the upcoming course offering. The investigation will be conducted using User Experience Questionnaire method. This study significantly contributes to the readiness of teaching and evaluation methods for future students, particularly in uncertain situations such as pandemic and endemic scenarios, in which lectures and students face numerous challenges such as internet access, community engagement restrictions due to Covid19 pandemic, increasing workloads, and more to be named.

2.0 LITERATURE REVIEW

2.1 Teaching Applied in Ergonomics and Safety for PDET

Applied Ergonomics and Safety course in University Malaysia Perlis course addresses ergonomics knowledge in product design. It explains the application of anthropometrics data in the design of products, equipment, and tools. Students will learn about fundamental knowledge of ergonomics, its applications in design and basic assessment tools to analyze design problems. The course also exposes students to specific considerations, needs or requirement for special populations such as the elderly and the disabled in the design. It also investigates ergonomic hazards, safety analysis & prevention, and the product safety. At the end of the course, the students are expected to obtain four course outcomes (CO) including CO1: Ability to define and apply the ergonomics fundamental and principles, and body mechanics in workplace and product design process; CO2: Ability to recognize suitable assessment tools and method to evaluate ergonomic issues; and CO3: Ability to generate and propose an effective design solution to enhance product intervention, usability, productivity, and safety.

2.2 Service-Learning Malaysia- University for Society (SULAM)

John Dewey established SULAM, a service-learning strategy, in the late 1960s [2]. However, in the first part of the twentieth century, a complete model of the service-learning concept and practices was produced. Dewey laid out three philosophical principles for service learning in his early educational writings, which were related to the importance of experiential learning, the need for reflection on service-learning practices, and the third requirement of stakeholders' active participation in the service-learning process, such as teachers, students, and the communities directly benefited by the service. The SULAM program was implemented in tertiary education, particularly in the public universities. The Quadruple Helix model was introduced as the fundamental concept for SULAM implementation, with every integrated SULAM course urged to involve students, lecturers, local

community, local industry, government agencies, or non-profit organizations in problem-based learning activities.

2.3 E-Learning Approach in Design Courses during COVID-19 pandemic

Due to COVID-19 pandemic, the learning approach has been changes to E-Learning approach. Despite the reality that the teaching technique saves time, space, and energy, the lack of interactions with colleagues has a significant influence since the design nature process cannot be delivered appropriately. Since World Health Organization (WHO) recommendations and countries' health systems required lockdown of activities and social distance to flatten the infection curve, individuals were forced to endure various changes in their daily lives as a result of the sanitary emergency caused by the COVID-19 virus. Students and teachers who had to convert traditional "in person" classes into online courses encountered many obstacles in terms of educational delivery[3] However, this cannot and should not be used as justification for establishing an educational strategy based on online teaching, considering teachers are not properly trained for it, and it was not their choice to do otherwise.

In spite of varies from other approaches in that it endeavours to tailor the product (in this case, an online educational game) to the end user's needs and interests rather than imposing qualities conceived by the designers [4]. Despite previous research, which focused on shared knowledge in small teams at a fixed period, the cognitive team approach proposed a scalable and dynamic learning approach. Avnet, M. S., & Weigel, A. L. establish a network of shared mental models by quantifying team members' similar thoughts of design drivers to reveal the structure of shared knowledge at a particular time. A metric of change in shared knowledge is generated based on a structural comparison of networks at different times in time [5]. The approach is best adapted to be used in HFR in PDET teaching and learning applications.

Sana et al. then investigated a design course for grade one students at Tishk International University's Interior Design department, analysing the questioner in order to establish ways and approaches for distance learning during a pandemic [6]. Students and teachers did not acclimatize well to online courses when it came to practical classes as opposed to theoretical ones, according to the findings. It was due to the fact that practical courses necessitated a hands-on approach in order to be

truly effective. Face-to-face interaction is very important since it does not require a fast internet connection to receive or offer feedback, comments are not lost in translation, engagement is increased, and overall communication is more active and livelier.

Regardless, innumerable questions occur as a result to understand the critical success factors variables that could play a significant role in effective online learning:

i. How to increase online learning effectiveness and efficiencies for the students and teachers?
ii. Which are the most suitable tools to be use in teaching and learning process?
iii. Does online learning suitable for certain courses that require practical interaction communication?
iv. Can online learning eliminate common learning approach?
v. How does online learning influence individual communication skills, emotions, and educational growth?
vi. How can online learning be made available to all students without being exaggerated?

Chen et al. studied into seven key online education platforms before and after the COVID-19 epidemic, utilizing emotional analysis, hot mining technology, and relevant [7]. The findings suggest that users were concerned about the platform's access speed, reliability, and timeliness of video information transmission before the pandemic, and that the cognition team approach using Zoom Cloud platform provided the best user experience. Users focused on course organization, communication and interaction, learning, and technical support services on the platform once the pandemic broke out, and the user experience on the platform was the most crucial component. It is suggested that the platform should be designed with a split screen so that users can simultaneously interact with the platform, thus timely and effectively share and interact with information resources. Third, optimize the ease of use of digital assignment and submission for mobile learning and pop-up video learning. Finally, enrich the platform resources to cover all disciplines. In addition, most course activities can be added to the platform to continuously improve the enthusiasm of learners.

3.0 METHODS

A comprehensive literature study was undertaken to discover common teaching and learning approaches for PDET in comparison to online learning after the COVID-19 epidemic sparked by implementing. By using [8] approach, a systematic literature review was conducted by dividing the process into three main phases: planning, conducting the review and reporting the results as summarized in Figure 3.1: Systematic literature review framework. An initial conceptual analysis process has been investigated, which is developed from an early approach to the general research problem; this conceptual analysis is carried out from the proposal of the conceptual mind or graphic model analysis to understand a specific field of study, and this resource will guide the entire process of organizing the search, and discrimination from inclusion and exclusion criteria. A comprehensive teaching approach in HFE related in PDET is reported.

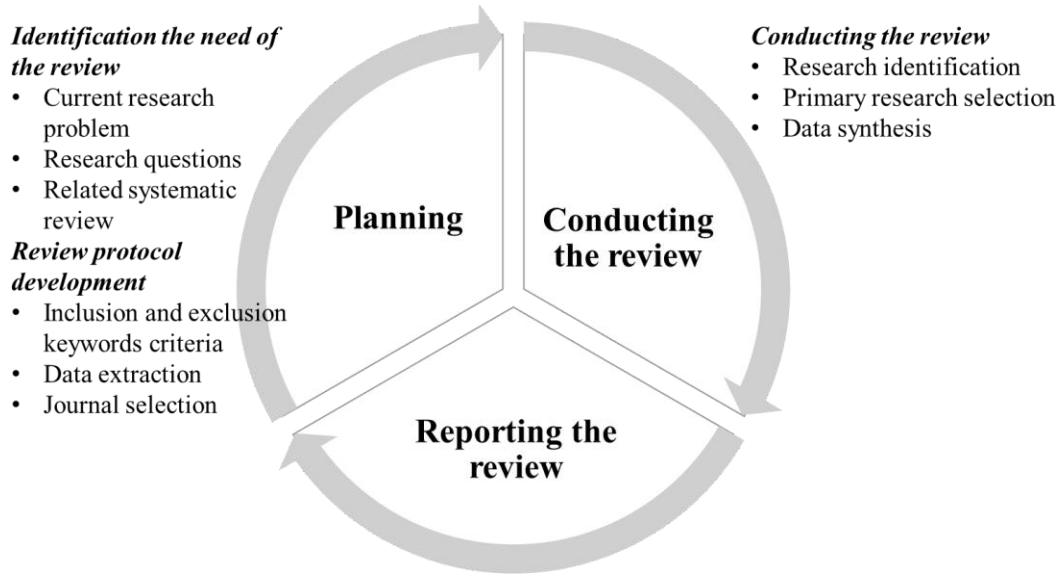


Figure 3.1 Systematic literature review framework [8]

30 students had been registered in Applied Ergonomics and Safety in 2021 in PDET. Only 25 students participated in the study feedback. The participated students were registered under the Bachelor of Mechanical Engineering Technology (Hons.) (Product Development) program in Faculty of

Mechanical Engineering Technology, University Malaysia Perlis. The average age of students was 21-24 years old male and female. The teaching and learning process was conducted by using physical face to face approach for the first four weeks which was then switched to an online learning strategy for the remainder of the semester. The teaching and learning components included of lecture, project-based learning (PBL) and labs. The service-learning approach was currently introduced in academic year 2021 after the faculty decided to embed the SULAM program into PDET course. Common practice implied 70 hours of physical lectures and lab teaching delivery hours throughout the semester. Despite online learning took place the teaching approach has been change to 38 hours per semester in synchronous mode and 5.6 hours per semester in asynchronous mode implying online lectures, online lab and online PBL using E-learning tools e.g., Google Classroom and Team Cognition tools: e.g., Google Meet, and Zoom. PBL is the teaching approach which embedded to SULAM requirement.

An OMR form was distributed via online at the end of the semester to obtain the feedback from students regarding the course and teaching satisfaction. OMR define 5-score scales were used to define the satisfaction score, which was 1was strongly agree, 2 Agree, 3 neither agree nor disagree, 4 disagree and 5 strongly disagree.

The evaluation User Experience Questionnaire (UEQ DIN ISO 9241-210) was distributed to examine the perceived quality and student experiences to ensure a user-centred application of such online learning adaptation in teaching and learning strategy for assessment. The UEQ Data Analysis Tool and Framework Analysis were used to analyse user experience.

5.0 RESULTS

5.1 Current teaching and learning approach in PDET

Numerous teachings approached has been changes significantly due to technology development and COVID-19 pandemic. However, HFE in PDT demand a tremendous interaction within the lecturer-student and community to understand the product need and requirements. Teaching approach in HFE related in PDET revolution is summarize in Table 4.1.

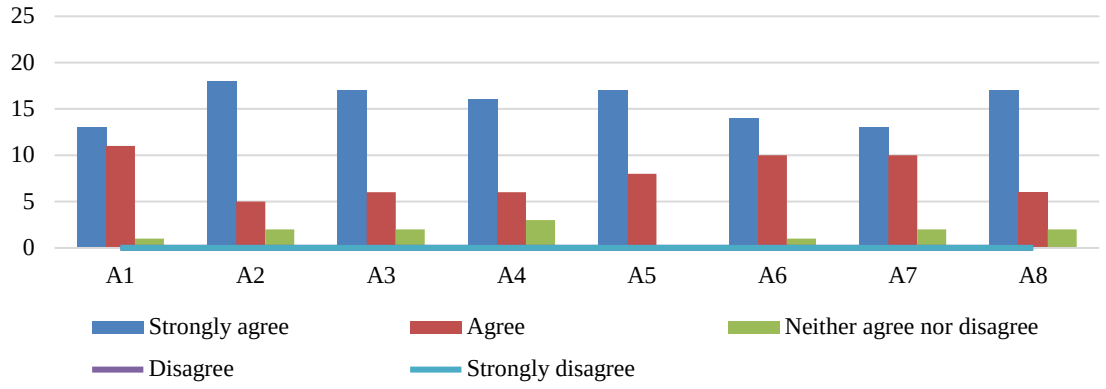
Table 4.1 Teaching approach in HFE related in PDET.

Author	Teaching Approach	Advantages	Disadvantages
(Naddeo et al., 2021)	E-Learning	Save Time, Cost, and Space	-Absence of interactions with colleagues
(Mohammed et al., 2021) **(Chen, T., Peng, L., Jing, B., Wu, C., Yang, J et al., 2020)**	Team Cognition	Increase communication engagement.	-Problems in educational teaching delivery
(Giraldi, L., Benelli, E., Maini, M., & Morelli, 2019)	Learning by doing	-Good practices to design enhance quality experiences on education [9] -Integrate learning and teaching methods in pleasant experiences, improving awareness among the users.	
(Almendra, 2013; Chiew & Salim, 2003; Dias et al., 2015; Landa-Avila & Aceves-Gonzalez, 2019; Liem, 2015)	Inclusive Design	-Design logbook facilitated student metacognition after activity [10, 11] -Student recognized the learning module give great impact [11, 12]	Student: -Complexity of reading scientific papers slow the design process, students -Felt overwhelmed with the responsibility to find a meaningful solution Teacher: -Increase time to communicate and teaching
(Sperano, I., Roberge, J., Bénech, P., Trgalova, J et al. 2019)	Journey Mapping	Student: -Help project planning along the design process Teacher: -A collaborative design tools -Support the creation of pedagogical activities [13] -Explore perceived quality	
(Lohse, A., Aust, A., Röder, J., & Bullinger, 2018) **(Anselmi et al., 2012; Liem, 2015; Na, 2010; Naddeo et al., 2021; Shieh, M. D., Tsai, J. L. et.al , 2021; Taylor & Mozrall, 2004; Ward, S., Wright, 2017)**	Mixed-Method Integrating Interdisciplinary	- Effective ideation method [14] -Collective creativity for teaching [15, 16] - User sensory emotional factor support [17] -Emotional evidence: Influences on happiness from the frequent positive visual exposure; the design process in design studio work [12] -The student more prepared to fulfill market demand [18].	-Should be more practical than theoretical -Shouldn't be taught and practiced in an isolated way

Throughout most instances, teaching and learning HFE in PDET required an interdisciplinary approach. The nature of this course relies on tremendous interaction within the lecturer-student and community. Inclusive design approach and integrating interdisciplinary approach has been a tradition vila for the course employment. The course will be enhanced more by implementing SULAM into the syllabus requirement using online learning and team cognition approach.

5.2 Students Satisfaction Evaluation.

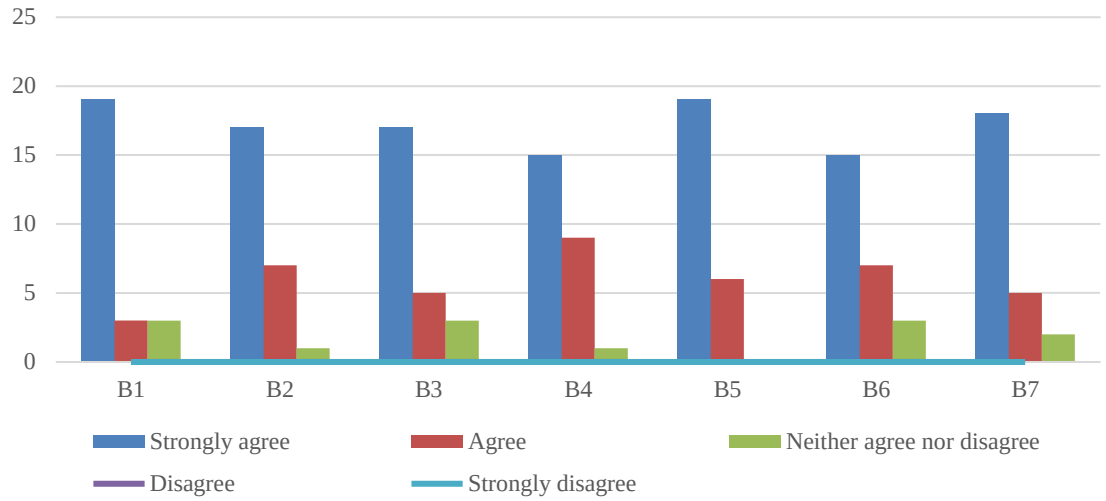
Figure 3.2, 3.3, and 3.4 shows the results of OMR score on course satisfaction in second semester of 2021. The course criteria that had been assessed were students' interest in the subject, the students' understanding of the subject, the course organization, the adequacy of handout, exercise or assessments given, the usefulness of workshops, seminar, tutorial, practices etc. and the achievement of all course outcomes (COs). Based on Figure 3.2, 93.5% students are satisfied with the course 62.5% from 25 students strongly agree and 31% agree the course is highly satisfaction compared to 6.5% are neither agree nor disagree. The highest of 72% students strongly agree the course has given good understanding about the subject based on criteria evaluation of A2. However, 12% of students neither agree nor disagree handouts/exercises/assessments given were adequate to the course. This shown that additional handouts/exercises/assessments need to be improve in adapting to online learning approach. 56% of the students strongly agree they achieved CO1, 52% strongly agree they achieved CO2 and 68% of the students strongly agree they achieved CO3. These findings will then compare to the student overall result at the end of the course.



A1 The course has developed my interest in the subject.
A2 The course has given me a good understanding of the subject
A3 The course was well organized
A4 The handouts/exercises/assessments given were adequate
A5 The workshops/seminars/tutorials/practices/etc. were useful
A6 I have achieved Course Outcome No. 1 (CO1)
A7 I have achieved Course Outcome No. 2 (CO2)
A8 I have achieved Course Outcome No. 3 (CO3)

Figure 3.2 Course Satisfaction Evaluation

Extensively, the course syllabus covers six main topic including introduction of ergonomics in design, human capacity and biomechanics in design, ergonomics and evaluation, design for usability and user-centred design, design for health and safety, design of equipment and hand-operated devices and finally design for special population. Based on Figure 3.3, 92.6% of the students are highly satisfied with the teaching approach in this course with 68.5% are strongly agree and 24% agree. However, 7.4% are neither agree nor disagree upon the teaching satisfaction. 76% of the students strongly agree the course syllabus was clearly presented and the lecturers are punctual to the class. 36% of the students neither agree nor disagree the correlated assignments and tests were made available to the students. This shows that some assignment and test need to be enhanced in suitability to online learning approach. 72% of the students strongly agree to rate a good performance on teaching satisfaction throughout the course.

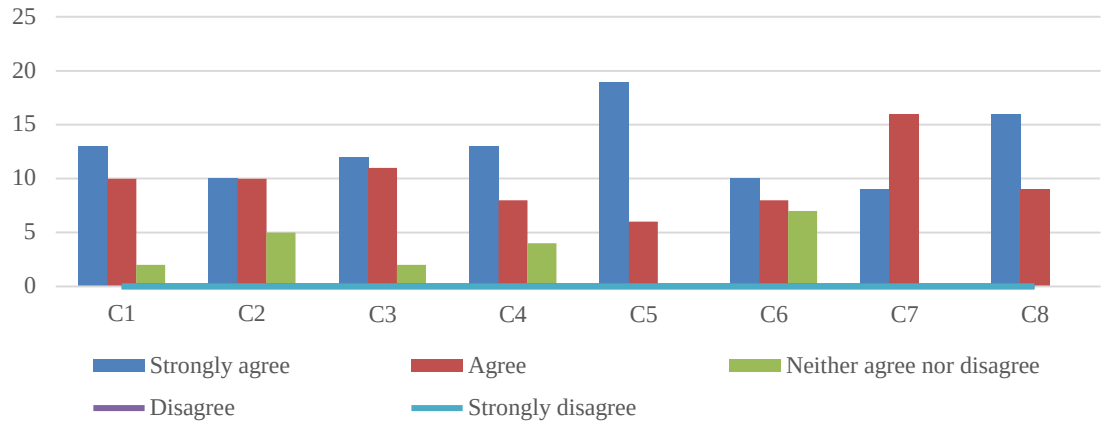


B1 The course syllabus was presented clearly to the class.
B2 The lecturer demonstrated knowledge and competence in the subject matter.
B3 The lecturer gave sufficient practices to test my understanding of concepts and principles.
B4 Correlated assignments and tests were made available to the students.
B5 The lecturer was punctual for classes.
B6 The lecturer is easily available for consultation.
B7 Overall, I would rate the lecturer's performance as very good.

Figure 3.3 Teaching Satisfaction Evaluation

In practice, this course embedded four labs consist of anthropometric lab, initial and advanced ergonomics risks assessment lab, hazard and risk assessment lab, and study and design of different types of hand tools lab. PBL approach was also conducted with 40% marks contribution throughout the

course. Based on Figure 3.4, 51% of students highly agree with the lab approach satisfaction, whereas 10% neither agree nor disagree. This shown that the online lab approach requires amendment to support online learning approach.



C1 Labs help me in understanding course concepts and principles (theory).
C2 Labs help me in understanding application of theory.
C3 Lab tests and presentation help me in understanding course theory.
C4 The PLV is very helpful.
C5 The PLV is punctual for labs.
C6 The PLV demonstrated knowledge & competence in the subject matter.
C7 Correlated lab reports and test were made available to the students.
C8 Overall, I would rate the PLV's performance as very good.

Figure 3.4: Lab Satisfaction Evaluation

Table 3.1 tabulated the overall course outcome marks contribution and Course Outcomes Attainment results. The course practices 100% continuous assessment consisting of Test, Lab and SULAM PBL. The result justify all COs was attained with CO1 61.1%, CO2 76.73%, and CO3 74.13%. SULAM PBL has been identified to be the highest attained with 29.67% compared to Lab 2 is the lowest with 13.41% attained. The data shows that online practical engagement project with community is more affective learning approach in comparison of online lab module. However, the students COs satisfaction feedback is contradicted with the results.

Table 3.2 Course Outcomes Marks Contribution

	Marks Contributions (%)	CO Attainment (%)
CO1	**30**	61.1
Test 1	11.43	
Lab 1	4.28	
Lab 2	2.62	
C02	**30**	76.73
Test 2	16.51	
Lab 3	3.42	
Lab 4	3.09	
C03	**40**	74.13
Project	21.85	
Presentation	7.82	

The result also revealed that community engagement is can also being conducted using online learning and team cognition approach with emphasizing correct tools and good planning throughout the project.

5.3 Results Perceived User Experience Questionnaire (UEQ)

Twenty-one (21) male and female students from thirty (30) overall students participated to answer the User Experiences Questionnaires (UEQ). Seven questions in related to online learning has been distributed using google form to get the feedback. Based on Figure 4.1, 95.2% student agreed SULAM is important to be implied into undergraduate syllabus. Student feedbacks reveal that community engagement helps the student to better understand user need and requirement in designing for community. 100% students agreed HFE knowledge awareness is relevant to be spread to the community through the SULAM Project. However only 47% students agreed SULAM project implementation is suitable to be conduct using online approach compared to 52% of students disagreed.

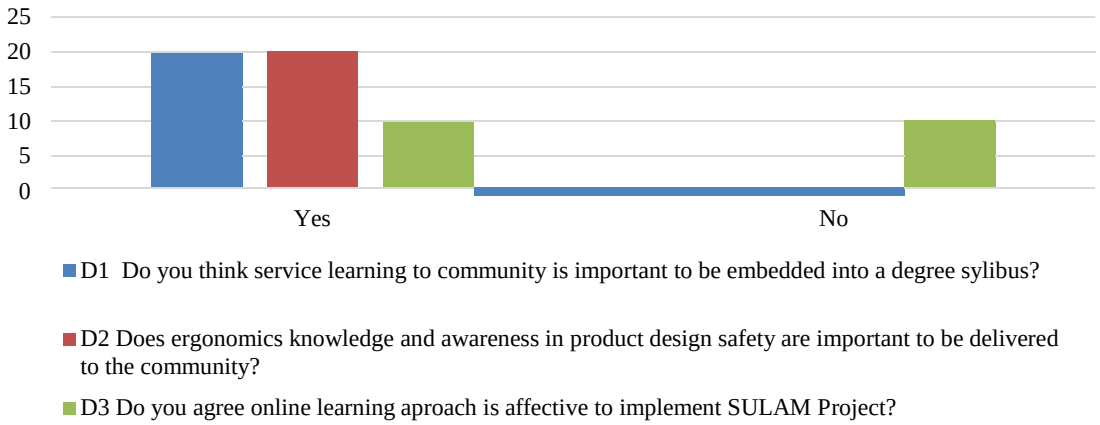


Figure 4.2 UEQ results for D1, D2, and D3

The UEQ also investigate the affective tools used during the period in implementing the SULAM Project online learning approach. As a results, most of the students used Zoom, Google Meet, WhatsApp, and Instagram to successful driven the SULAM Project. The tools have been used for community engagement with the students to collect user problems, needs and requirements to improve better design solution. Few students use Webex, Telegram and Facebook.

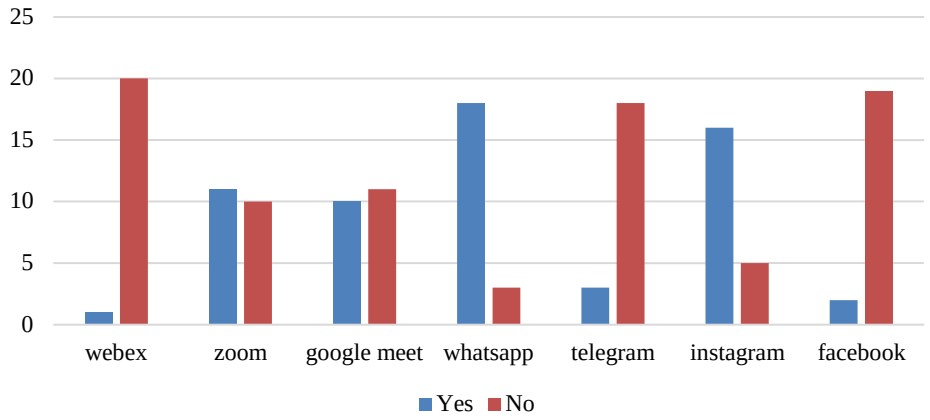


Figure 4.3 Effective online learning tools for HFE and design course

Due to encourage community engagement using online platform, some suggestions derive from the students. 52.5% student suggests spreading video awareness, 14% suggest online meetings with community and spreading poster could help to increase community engagement as seen in Figure 4.3. 4% students agree e-certificate would be effective to increase good community engagement.

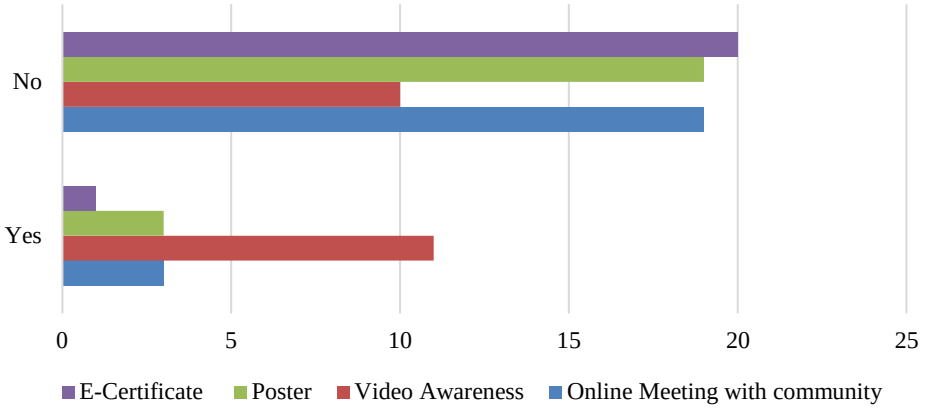


Figure 4.4 Suggestions to increase community engagement

6.0 DISCUSSION

6.1 Results of course, teaching and lab satisfaction evaluation

The adoption of changes for course coordinator to clearly understand the entire process of the service-learning approach has become a major challenge in course management, teaching, and assessment. They were under a tremendous pressure to develop the course content by changing documents such as the HEA-03, Self-Learning Time (SLT), and Teaching Plan (TP), meeting with potential project stakeholders more recurrently, attending short courses and workshops for SULAM implementation, and attempting to put in extra effort in self-learning and research on service-learning methodologies. Unfortunately, both the course coordinator and the lecturers ran the IE course with no instructions as well as no prior expertise. The entire process become more complex when the COVID-19 epidemic struck the world at the end of 2019, right in the middle of the teaching and learning process, as many experts and educators have discussed [3, 4, 6, 7, 19]

However, after implementing SULAM in other courses during the first instance, both before and during the epidemic, the course coordinator has acquired more creative, experienced, knowledgeable, and organized in administering the SULAM approach for design course in academic year 2021. This explains why the mean satisfaction for course, teaching and lab is expected to increase in 2021.

The satisfaction percentage in CO1 i.e., ability to define and apply the ergonomics fundamental and principles, and body mechanics in workplace and product design process is 56%, CO2 i.e., ability to recognize suitable assessment tools and method to evaluate ergonomic issues with 68% satisfaction,

and CO3 i.e., generate and propose an effective design solution to enhance product intervention, usability, productivity, and safety is 68% highly satisfied.

Physical lecture and discussion have been identified to be the most effective form of communication between teachers and students in understanding course content when opposed to virtual classes [6]. Finally, the highest satisfaction score in the course organization criteria highlights the effect of the digital platform in organizing course materials and documents, such as submitting assignments to the cloud, sharing references and lecture notes in the digital classroom, and comparing previous course organization to previous teaching and learning methods that used paper-based submission.

6.2 Results of students' grade with online learning approach aligning SULAM implementation in comparison to students' satisfaction.

The study has identified that all COs has attained above 50% in PDET course applying the pedagogy or SULAM approach, and there are no significant effects on COVID-19 pandemic factor. The findings also justify that the SULAM approach helps students to more understand inapplying ergonomics knowledge in designing products, increase the ability to analyse and perform the given PBL SULAM Project. Students also able to choose suitable assessment tools, solving the design problems and propose solutions for the community.

Table 3.1 shows the students grades attained all the COs above 50% contributing the test, lab and SULAM PBL Project. However, the findings reveal a discrepancy in students' satisfaction with lab evaluations. This indicates the students are significantly unpleasant with online learning lab teaching and approach.

6.3 Results of Perceived User Experience Questionnaire (UEQ) of online learning for PDET course.

Referring to Figure 4.1, 95.2% of students agreed SULAM should be included in undergraduate courses. According to student response, community engagement aids students in better understanding user needs and requirements while designing for the community. 100% of students concede that

spreading HFE knowledge awareness to the community through the SULAM Project is important. However, barely 47% of students agreed that the SULAM project should be conducted through an online approach, while 52% neither agree nor disagreed. Most of the students successfully encounter the challenge by adopting online learning and team cognition approach throughout the semester. Appropriate tools of online learning play a significant role of the success. The students persuade to utilize Zoom, Google Meet, WhatsApp, and Instagram to increase Community engagement to the SULAM Project. It is proposed that servicing the community could be advocated through an online meeting, a video awareness campaign, and spreading a poster. Other factors that significant to influence the teaching and learning are internet access capability, skills of using online learning and team cognition tools and appropriate planning.

7.0 CONCLUSION

This study has successfully investigated critical success factors of implementing online learning approach in ergonomics product design course embedding SULAM Project during COVID-19 pandemic. Figure 4.1 shows that 95.2% of students agreed that SULAM is important to be introduced in undergraduate courses. Community engagement, according to student feedback, allows students better comprehend user needs and requirements while designing for the community. The significance of extending HFE knowledge awareness to the community through the SULAM Project is affirmed by 100% of students. However, approximately 47% of students agreed that the SULAM project should be conducted through an online approach, while the remaining 52% were uncertain. Throughout the semester, most students managed to overcome the obstacle by using online learning and a team cognition approach. Adequate online learning tools play a critical role in success. The students persuade the involvement of the community in the SULAM Project through Zoom, Google Meet, WhatsApp, and Instagram tools. It is recommended that community service be urge through an online meeting, a video awareness campaign, and the distribution of a poster. Internet connectivity availability, competence in using online learning and team cognition tools, and adequate preparation are other major elements that influence teaching and learning success factor of SULAM implementation into the course.

7.1 Limitations and future studies

The limitation of online learning; team cognition competencies and appropriate internet connectivity shall be available of student, teachers and community shall be further studied. As a result, it's essential to identify teaching and learning gaps to recommend continuous improvement for future implementation of the PDET course, which will serve as a reference for other courses in the SULAM course.

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