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Learning effectiveness of virtual land surveying simulator for blended open distance learning amid Covid-19 pandemic

by

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Abstract

Many universities worldwide were forced to physically close campuses due to lockdown and resumed the in-person classes compliant with a stringent set of SOPs as Covid cases drop. This has profoundly disrupted the hands-on lab face-to-face learning process that is harder to be moved online. Virtual simulation lab could be the answer and its use in many courses has been extensively studied. However, it is relatively little studied when it comes to land surveying courses. The purpose of the study is to explore the learning effectiveness of virtual surveying field lab for blended open distance learning (ODL) students at Wawasan Open University (WOU) in the time of Covid-19. This study used a mixed-method that combines qualitative and quantitative approaches to get a fuller picture and deeper meaning of learning behavior. Respondents were selected using the purposive sampling method. Survey questionnaires were designed and distributed to students before and after lab simulation class. Instructors were interviewed after the lab simulation class. Students' learning results for the surveying course were compared with the past-year examination results at pre-Covid-19 times before the virtual simulator was introduced. Both qualitative and quantitative data set were collected and analyzed together using descriptive and inferential statistical methods in SPSS platform. The findings revealed that the virtual simulator has enhanced students' learning interest and efficiency for surveying course in a ODL setting. Both students and instructors have responded positively towards the virtual simulator learning experiences. Students' achievement in the final examination amid Covid-19 was better than pre-Covid-19 performance.

Keywords: Covid-19, 3D simulator, Virtual laboratory, Land surveying, Blended open distance learning

1. Introduction

The abrupt outbreak of Covid-19 pandemic has forced many universities worldwide to temporarily close physical campuses due to lockdown and shifted the in-person classes to online mode. However, the practical lab class that requires hands-on and is more difficult to be moved online has to be halted and to be adjourned to a much later time. Even if the hands-on lab is forcibly moved online, the hands-on lab most likely has to go hands-off, leaving out the hands-on experience whereby students passively watching the demonstration videos from the instructors, that either live or pre-recorded. Like the other countries, Malaysia resorted to the extreme measures to curb the spread of the Covid-19, began to implement the unprecedented lockdown starting in March 2020 until May 2020 with the gradually eased lockdown restrictions. Universities in Malaysia, public and private, have not been spared from the impacts of the Covid-19, were ordered by the Higher Education Ministry to stay shut physically and to go fully online until end of 2020, with a few exceptions that let students who need to carry out practical laboratory work using specialized equipment to enter the campus, subjected to the stringent set of standard operating procedures (SOPs). (MOHE, 2020) In January 2021, following a second wave of Covid-19, much of the country again was into its second major lockdown. The whole nation was plunged back into a full lockdown in June 2021 as third wave hit. In virtue of the national vaccine rollout success, universities finally opened their campus doors to fully vaccinated students to return starting Oct 2021, but still with strict SOPs in place. (MOHE, 2021) Admittedly, with many uncertainties and the ups and downs of repetitive lockdowns, the Covid-19 pandemic has indeed profoundly disrupted the whole educational system and in particular, the hands-on lab face-to-face learning process.

Nonetheless, the land surveying hands-on outdoor lab has faced its own unique challenges even before the Covid-19 pandemic. (Kuo et al., 2007; Mills and Barber, 2008; Lu et al., 2008; Kang et al., 2010; Hazar and Nicoletta, 2011; Gao and Wu, 2017; Bolkas et al., 2020; Tingerthal and Kaoni, 2021) The physical surveying instruments that are generally sensitive and delicate have to be handled with great care, but wear out despite years of good maintenance, and get expensive when replacing with more up-to-date or higher quality one. Insufficient quantity of the physical surveying instruments leads to the unequal access to the instruments when students are asked to practice in bigger groups. The practical session is further bounded by the location within the vicinity of the campus with the same terrain characteristics due to accessibility and safety issues; the unpleasant external environmental conditions like haze or rainy weather especially in this tropical climate zone; and the allotted time for the hands-on lab to cover fairly each surveying topics in the course syllabus. The demonstration on the operation of the surveying instruments from the instructors may not be seen clearly by the students in the field, particularly some detailed operation steps with tiny finger motion like setting up the instruments. After the demonstration, students are usually dispatched in groups to carry out the fieldwork, often with little supervision, in the end, are asked to report their fieldwork results to the instructors and have no way to trace back their multi-steps process. All these factors have thrown wrenches to the learning process in getting students to familiarize with the use of modern surveying instruments and preparing them adequately for surveying work in the real world. With these challenges in mind, virtual land surveying simulator seems like the perfect solution. But then in-depth study on the learning effectiveness of virtual surveying simulator should be conducted before incorporating it into the land surveying course curriculum. Recognizing the value that comes after it, this study kicked off way before Covid-19. While working on the solution, this study proved to be very timely during the nationwide shutdown of on-campus teaching due to the Covid-19 surge.

2. Literature review

Ever since the emerging of this new virtual reality technology, computer generated simulation has been exponentially increased its use in many education and training courses involving hands-on laboratories in wide spectrum of fields, in particular, dominating mainly in science, engineering and medical, leading the trend by renowned universities and institutions like Massachusetts Institute of Technology (MIT), Carnegie Mellon University, to name a few; and its application has been extensively studied in the literature review over the past decade, showing great deal of interest in this topic worldwide. (Freina and Ott, 2015; Potkonjak, V. et al., 2016; Salmerón-Manzano and Manzano-Agugliaro, 2018; Checa and Bustillo, 2020; Shalaunda and Kent, 2020) In architecture-engineering-construction (AEC) education, the underpinning VR technology has been adopted to support design, visualization, structural analysis, hazards recognition, safety training, decision-making, operational training of heavy equipment such as cranes; without facing the dire do-or-die consequences as in real construction project. However, there have been relatively much lesser studies of its development and implementation when it comes to architecture-engineering-construction education, especially for land surveying courses, in an open distance education setting, to say the least. (Chi et al., 2013; Rahimian et al., 2014; Li et al., 2018; Wang et al., 2018)

Therefore, several successful attempts to explore in-depth the virtual laboratory for construction surveying are deemed valuable and commendable. Using QuickTime VR technology, Ellis et al. (2006) implemented an interactive multi-media learning resources for leveling survey only and evaluated its application among undergraduate students in the School of the Built Environment at Leeds Metropolitan University. Mills and Barber (2008) employed virtual interactive learning tool running on AJAX for traversing survey only at Newcastle University's School of Civil Engineering and Geosciences. In addition to levelling and traversing, a virtual simulator for survey training, SimuSurvey and an improved version using XNA gaming platform, SimuSurvey X, were developed at the Department of Civil Engineering in National Taiwan University that cover other surveying topics as well. ((Kuo et al., 2007; Lu et al., 2007, Kang et al., 2010) In the College of Technology at Purdue University, a virtual learning environment was created and a pilot study with undergraduate students was conducted for one chaining module only in surveying fundamental course before extending to differential level surveying module. (Hazar and Nicoletta, 2011; Hazar et al., 2014) Gao and Wu (2017) designed an experimental virtual surveying system using VR modeling language for students in Henan University of Urban Construction. León and Morales (2018) created interactive survey instructor (ISI) that was being used by the surveying engineering school from University of Costa Rica for teaching two modules only, differential leveling and traversing. In response to the Covid-19 pandemic, Tingerthal and Kaoni (2021) prepared a virtual laboratory centered on a series of interactive videos for students at Northern Arizona University, without the gamifying survey experience that allows students to operate virtual instruments. Whereas Bolkas et al. (2021) presented surveying reality (SurReal) software solution that simulated the virtual reality environment and surveying level instrument in an immersive and interactive virtual laboratory based on levelling task only at Pennsylvania State University Wilkes-Barre campus. Unmistakably, all the findings of these studies in recent decade bring forth positive results and reach a conclusion on the betterment of teaching and learning process with the use of virtual simulation laboratory for surveying.

3. Research Methodology

Basic surveying course is the basic major course within the undergraduate construction management program at Wawasan Open University (WOU). It is an introductory course to the fundamentals of construction surveying that comprises the basic principles and branches of surveying, the use of survey instruments such as auto level, theodolite, EDM, total station etc., the various common methods of surveying procedures such as levelling, traversing, bearing etc.; and the applications of surveying in building construction. Students from main campus in Penang and four geographically apart study centers at different locations in Perak, Johor, Kuala Lumpur and Sarawak, are required to take this basic surveying course in the first year of their studies and to complete it in one semester. In year 2020, there were 208 active current undergraduate construction management program students and about 30 of them taking basic surveying course in each year cohort. These students were invited to participate in the virtual surveying field lab simulation class, along with 21 graduating students and 53 graduated students as well, so to compare between those with and without prior knowledge of surveying background.

Being an ODL university, WOU robust virtual learning spaces are naturally flexible and accessible to cater to students' online and remote learning experience as shown in Figure 1, even despite the interruption brought about by Covid-19. Learning management system (LMS) at WOU uses MOODLE that delivers one stop service for students. (Chew et al., 2017) Through the LMS gateway, the surveying course page provides for students all the surveying materials at one place including surveying course materials, lab manual, lab procedures, demo videos and animations, quizzes, course assignments, past year exam papers, online forum, announcements, additional web resources, library learning resources etc. On the other hand, for instructors, it provides LMS analytic reports of users' access and views, customization, instructor supports, helpdesk etc. However, there have been physical surveying field labs with practical training initially conducted on-campus that had to go online due to the nationwide shutdown of on-campus teaching. As such, the virtual surveying lab simulators that are available to students and instructors to install onto personal computers / laptops or to access it through local network remotely made it possible for online surveying lab classes to continue effectively.

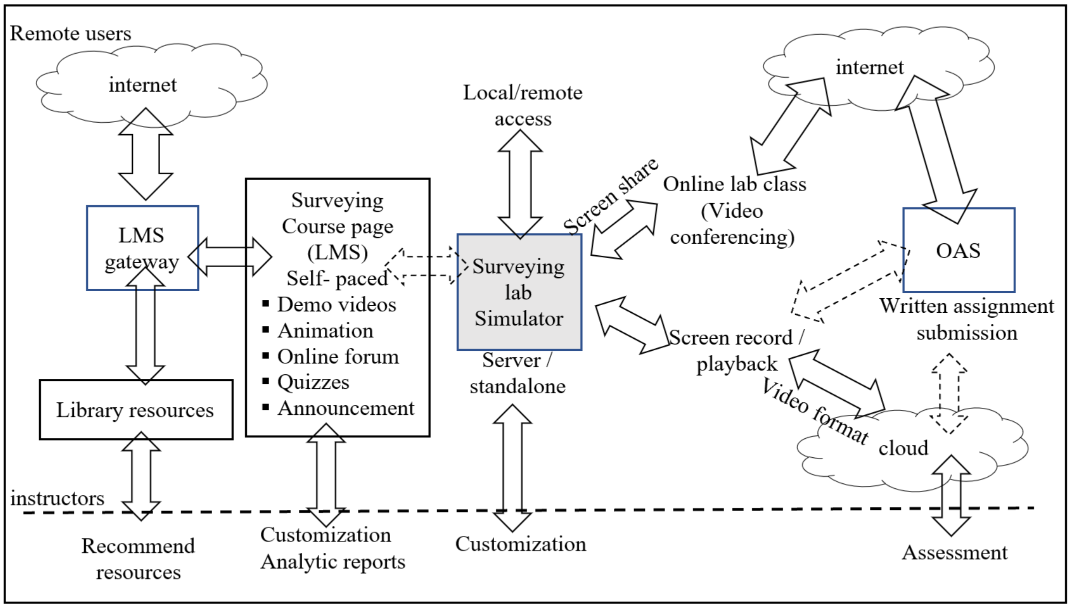

Figure 1: Ecosystem of virtual learning platforms for surveying courses

Amid the Covid-19 pandemic, virtual land surveying simulator was introduced for the first time to students before the physical surveying field lab class was conducted on WOU main campus and four regional learning centers, with the stringent SOPs in place such as masking, temperature screening, social distancing, MySejahtera scanning etc. After the first introduction, students would then access it remotely by downloading and installing the virtual simulator onto their own personal devices or to access it through local network, for their own practices. The virtual surveying simulator used in this study is SimuSurveyX, an improved version of a computer-based survey surveying simulator, SimuSurvey that was first developed by researchers from Department of Civil Engineering in National Taiwan University using OpenGL graphic library and the C# object-oriented programming (OOP) language. (Lu et al., 2007) A feasibility study on the original version of the virtual surveying simulator was conducted. (Kuo et al., 2007) Following that, the user interface of SimuSurvey was then redesigned by using user-centered design (UCD) approach. (Lu et al., 2008) The original version was further improvised by using XNA gaming platform. SimuSurveyX provides a virtual environment and simulates various surveying instrument and accessories for users' manipulation controlling like auto level, theodolite, total station, tripod, reflector prism, level staff and ranging rod. It covers five basic surveying training activities namely leveling, horizontal angle & vertical angle surveying, traversing and free mode surveying. (Kang et al., 2010)

Prior to the virtual surveying field lab simulation classes with students, instructors attended the training workshop on the operation of the virtual surveying instrument through the scheduled meeting online. Pre and post survey questionnaires were designed and distributed to the students before and after the virtual surveying field lab classes. There were three sections in the pre-survey whereas there were two sections in the post-survey. The instructors who are also the subject experts were interviewed after the virtual lab classes as well. The total respondents who have responded voluntarily to participate in this study are 28 students and 7 instructors of WOU. Both students and instructors were identified and selected as the respondents using the purposive sampling method. During the virtual lab classes, instructors gave demonstration and guided the students for five virtual surveying activities namely distance measurement, angle & direction measurement, levelling, traversing and calculation related to surveying, in order to achieve the learning objectives whereby students should be able to set up the virtual surveying instruments, to perform measurements using different virtual surveying instruments and to carry out calculation related to surveying.

At the end of the virtual lab classes, students were asked to answer the quizzes related to the surveying activities and their answers were graded. As the basic surveying course is offered at WOU every academic year, students' learning results for basic surveying course are tested again in the final examination at the end of the semester and these results were compared with the past year examination results at pre-Covid-19 times before the virtual surveying simulator was introduced. Mixed method combining qualitative and quantitative approaches is used in this study to get a fuller picture and to perceive deeper meaning of students' learning behavior. Both the qualitative and quantitative data set were collected and analyzed together using descriptive and inferential statistical methods in Statistical Package for Social Sciences (SPSS v. 28) software platform, with the primary objective to explore the learning effectiveness of virtual land surveying field lab simulation for blended open distance learning (ODL) students at WOU in the time of COVID-19 pandemic.

4. Results

The virtual surveying field lab simulation class were planned for construction management program students in year 2020, there were 208 active current undergraduate, 21 graduating students and 53 graduated students invited to participate the study. A total of 28 students responded. Two anonymous pre and post survey questionnaires were designed in the form of binary yes or no questions, multiple choices, a 4-point Likert-type scale, as follows, 1=strongly disagree to 4=strongly agree, and open-ended questions whereby their other comments were also welcome. In the pre-survey questionnaires, there were three sections. The first section was to attain the background of students that include age, year of studies, prior knowledge in surveying courses, work and surveying experiences etc. Overall, we had a good balanced distribution among participants with diversified demographic and background characteristics (Table 1).

Demographic characteristics		%
Age	20 – 34 years	50
	35 – 44 years	39
	45 – 54 years	11
Years of studies	Year 1 – 2	36
	Year 3 – 4	43
	Year 5 or more	14
	Graduated	7
Taken basic surveying course at WOU	Taking now	57
	Taken already	22
	Not taken	21
Taken land surveying course during diploma / technical / vocational studies	Yes	39
	No	61
Construction work experience	Less than 1 year	11
	1 – 5 years	36
	6 – 10 years	14
	More than 10 years	39
Surveying experience at workplace	Yes	43
	No	57

Table 1: Demographic characteristics of participants

The second section of the pre-survey questionnaires was to gauge students' attitude towards conventional surveying course without virtual surveying simulator that comprises of three parts: students' degree of interest in surveying course itself, their degree of interest in operation of physical surveying instrument and their challenges in handling the physical instrument. Students were asked to indicate their level of agreement with statements in this section. Using boxplot, Figure 2 - 5 illustrate the students' responses to the statements. Figure 2 shows that students generally were keen in surveying course itself, for example, statement 1: I am very interested in the surveying course (median=3); statement 9: the surveying course prepares me for the subsequent higher-level courses in my overall study (median=3); and statement 13: I think the surveying course is useful for my profession (median=3).

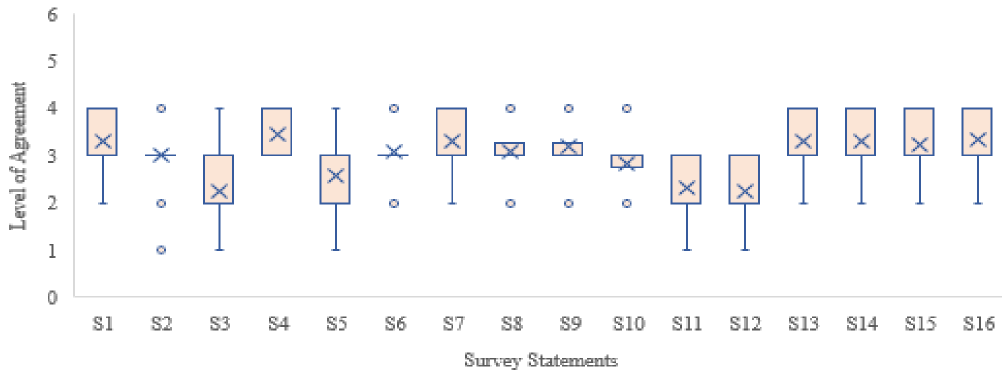

Figure 2: students' responses to statements regarding their degree of interest in surveying course

Figure 3 shows that students mostly were keen in learning how to operate physical surveying instrument, for example, statement 1: I am very interested in the operation of physical surveying instrument (median=3); however, majority of the students disagree statement 14: operating physical surveying instrument is easy (median=2); and they are willing to spend more time to practice on how to operate physical surveying instrument after leaving lab class in statement 18 (median=3).

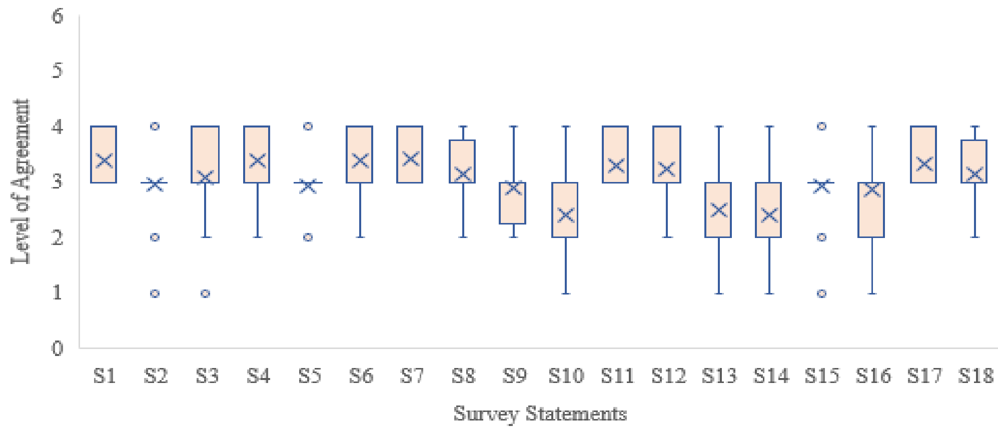

Figure 3: students' responses to statements regarding their degree of interest in operation of physical surveying instrument

Figure 4 shows that students faced many challenges in handling the physical surveying instrument, for example, statement 1: the physical surveying instrument is not enough for students to take turn to practice (median=3); statement 17: I want more interaction between instructors and students (median=3); statement 18: I need more guidance from instructor when I operate surveying instrument; and statement 20: I cannot understand without audio visual teaching aids used by instructor (median=3).

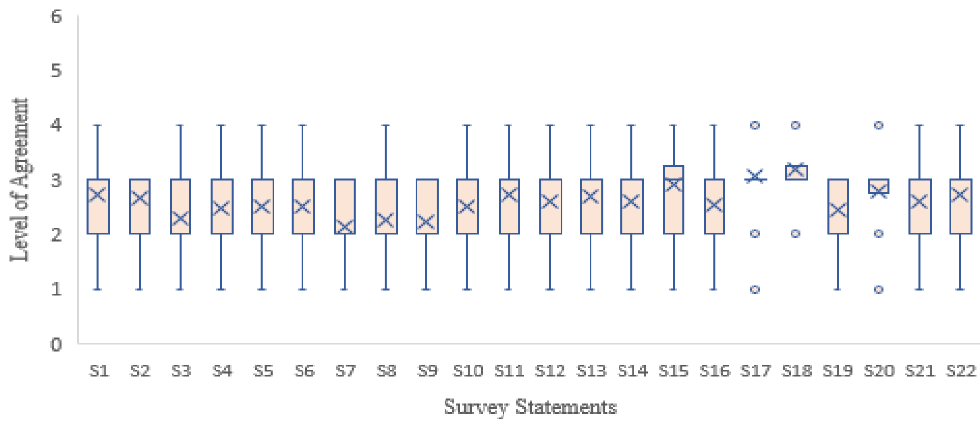

Figure 4: students' responses to statements regarding their challenges in handling the physical surveying instrument

The third section of the pre-survey questionnaires was to gauge students' attitude towards unconventional surveying course with virtual surveying simulator that comprises of two parts: students' degree of interest in learning how to operate virtual surveying instrument and their readiness to run virtual simulator on their personal devices such as their device types, window version, graphic card, internet connection etc. Figure 5 shows in general students were keen in learning how to operate virtual surveying instrument, for example, statement 1: I am very interested in the operation of virtual surveying instrument (median=3) and they are willing to spend more time to practice on how to operate virtual surveying instrument after leaving lab class in statement 16 (median =3). All the students possessed personal devices either laptop or desktop with Windows 7 and above. 61% of their devices have graphic card. 75% of the students had stable internet connection access and 86% of them were comfortable to download and install virtual simulator on their own.

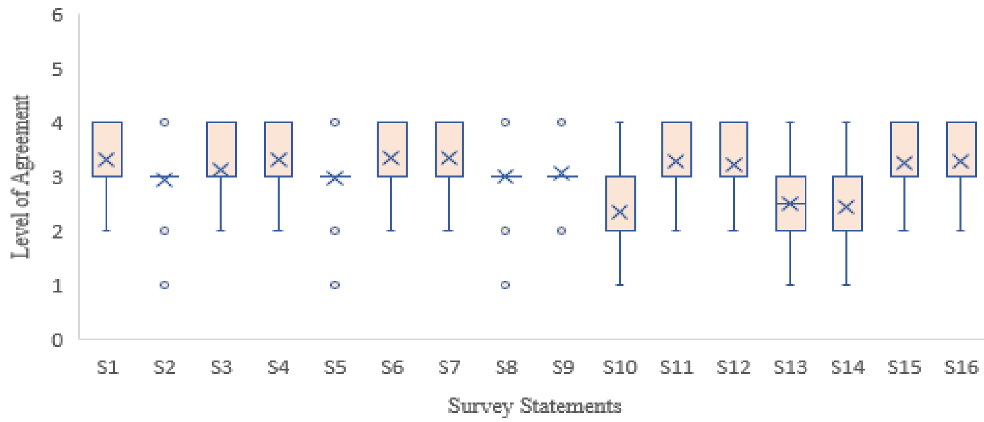

Figure 5: students' responses to statements regarding their degree of interest in operation of virtual surveying instrument

Whereas in the post survey questionnaires, there were two sections in the post-survey. The first section was to find out if any changes of students' attitude towards unconventional surveying course with virtual surveying simulator after participating the virtual surveying field lab simulation classes. This section comprises of students' rating on self-efficacy, effectiveness of learning, instructors, virtual surveying activities, virtual surveying software, lab manual and exercise provided during the virtual lab simulation classes. Figure 6 shows students' ratings and the students in general have responded positively towards the virtual surveying simulator learning experiences.

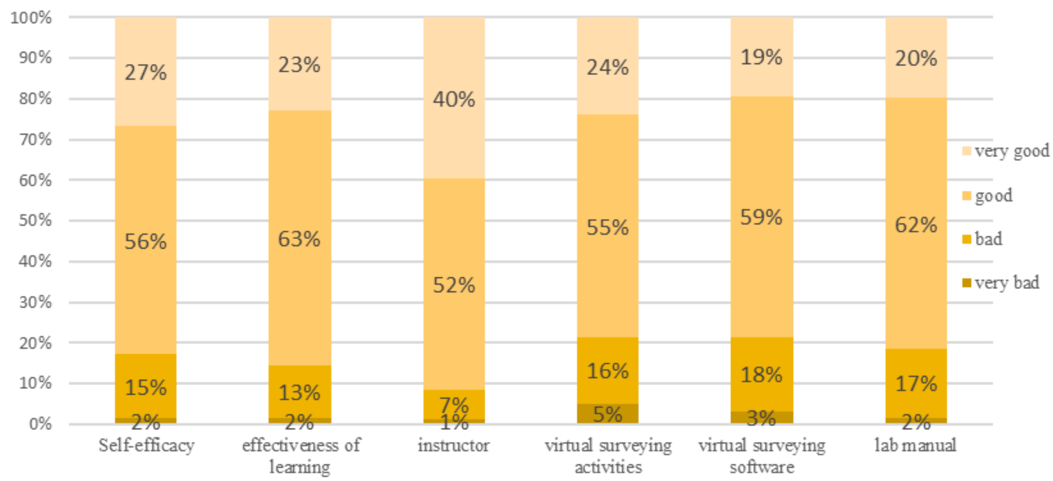

Figure 6: students' rating on their learning experiences towards surveying simulator lab class

Students were asked to indicate their level of agreement with 10 survey statements each related to learning interest and learning efficiency in surveying respectively. A parametric test i.e., student t test for dependent or paired t test was used to find out any statistically significant mean change in learning interest and learning efficiency of surveying following the virtual simulator lab class as sample size, $n < 30$. The distribution is normal after verifying with the Kolmogorov-Smirnov test as p-value > 0.05. The mean±SD of learning interest in surveying before surveying simulator lab class was 30.86±2.965, and mean±SD after simulator lab class was 32.21±3.985. There was significant mean change in learning interest of surveying after simulator class as *p*-value < 0.05 (*p* =0.022) (Figure 7). The mean±SD of learning efficiency in surveying before surveying simulator lab class was 26.86±3.608, and mean±SD after simulator lab class was 30.68±3.486. There was also significant mean change in learning efficiency of surveying after simulator class as *p*-value < 0.05 (*p* =<0.001) (Figure 7).

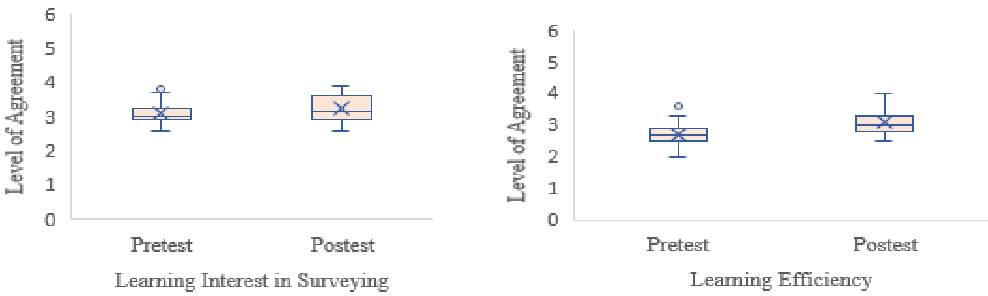

Figure 7: Comparison between students' responses for pre and post virtual simulator lab class

The second section of the post survey questionnaires was to determine students' preference between surveying course with and without virtual surveying simulator. Figure 8 shows that majority of the students agreed the surveying course with virtual simulator is better, corresponding to the challenges with the physical instrument, for example, statement 1: virtual surveying instrument is better because every student can handle the surveying instrument at their desktop (median=3); statement 17: virtual simulator is better because there is more interaction between instructors and students (median=3); statement 18: virtual simulator is better because instructor could provide more guidance when I operate surveying instrument; and statement 20: virtual simulator is better because instructor could use it as audio visual teaching aids (median=3).

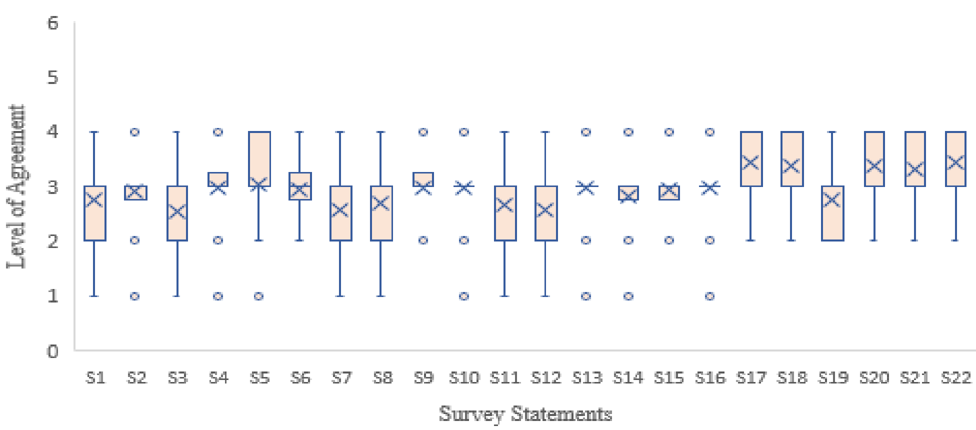

Figure 8: students' response to their preference between surveying course with and without virtual surveying simulator

5. Discussion

Besides reporting on the indirect method that captures students' perceptions of their learning experiences through survey questionnaire, a direct method involving an evaluation of students' quizzes in answering four different surveying topics upon completion of the virtual lab class (Figure 9) and also the comparison of the year end final examination results of surveying course with the past year results before the introduction of virtual simulator (Figure10), were also employed in this study.

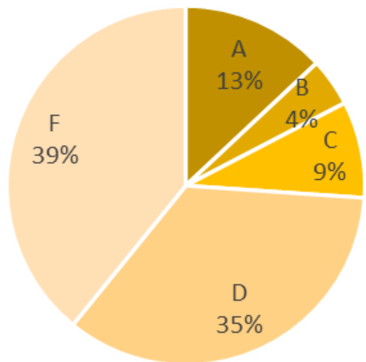

Figure 9: students' quizzes result at the end of the simulator class

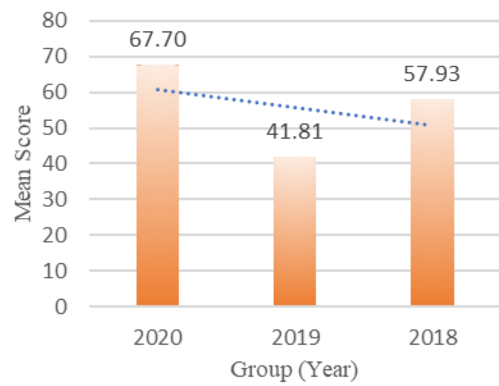

Figure 10: Comparison of mean scores for final exam results in year 2020, 2019 and 2018

Figure 9 illustrates that more than half of the students, i.e., 61% of them, passed their quizzes (average=44%), the lowest score for students who failed was 13% and the highest score was full mark, 100%. Majority of the students agreed that they had no difficulties in understanding the questions provided in the quizzes (median=3) and better understanding of the questions after carrying out the virtual surveying activities (median=3), but think they would be able to solve the questions if they have more time (median=3).

Figure 10 depicts that the mean±SD score for group in year 2020 is higher at 67.70±21.544 as compared to year 2019 (mean±SD=41.81±21.360) and 2018 (mean±SD=57.93±21.251). One-way ANOVA analysis confirms that there is a statistically significant difference between the mean score for each group as the significance value is 0.000 (p = 0.000), which is p-value < 0.05. The Tukey's HSD test i.e., the preferred test for conducting post hoc tests on a one-way ANOVA. The multiple (pair-wise) comparisons of scores between the groups shows that there is a statistically significant difference in the scores between year 2020 and 2019 (p = 0.000) and between year 2019 and 2018 (p = 0.029). However, there is no significant difference of the scores for year 2020 and 2018 (p = 0.198). In short, this proves that the virtual simulator lab class introduced to the group in year 2020 helped the students scored better in their final examination as compared to the groups not introduced with the simulator lab class in year 2019 and 2018.

While the virtual simulator was received positively by the students, instructors were also asked to give their rating on students' learning experiences that comprises of learning interest, learning effectiveness, interaction between instructors and students, virtual surveying activities, virtual surveying software, lab manual and exercise provided, based on their observation during the virtual lab class. (Figure 11) The instructors in general have responded positively towards the virtual surveying simulator learning experiences.

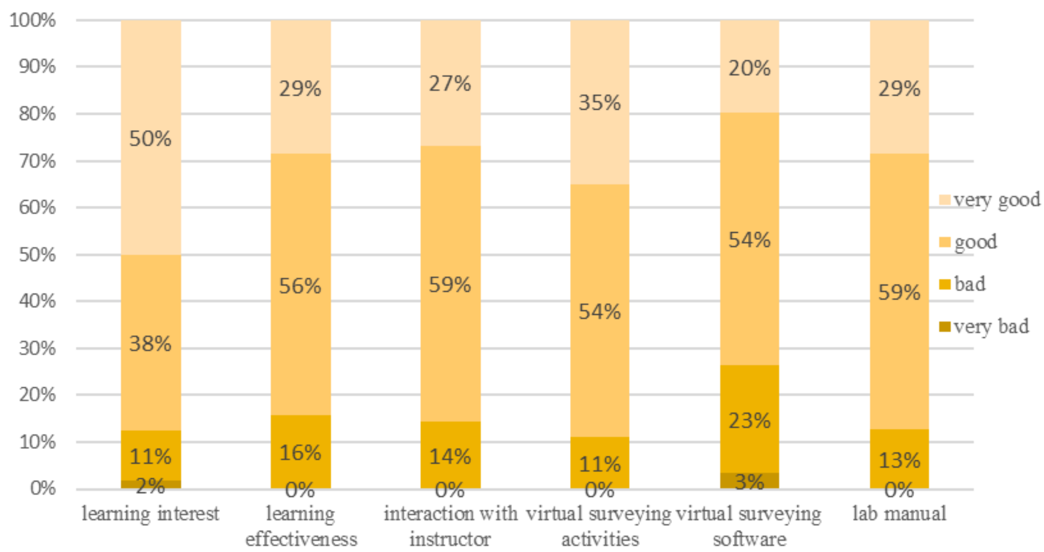

Figure 11: instructors' rating on students learning experiences towards surveying simulator lab class

These 7 instructors were interviewed after the virtual lab simulation classes to give their suggestions and feedbacks. The instructors observed that during the simulator class students paid full attention to them, the interaction between them and students were good, eventually students could clearly understand the learning objective and were able to operate the virtual surveying instrument as instructed. They also commented that during the learning process, virtual surveying simulator helped students to understand some of the surveying theories and concepts that are abstract.

The virtual surveying simulator allowed students to screen record the surveying activities history to the cloud / drive to share with the instructors in order to playback the recorded surveying activities to review students' learning problem and to provide constructive feedback. The instructors recognized that virtual surveying simulator comes in handy especially amid pandemic outbreak, so that students could still carry out the surveying activities, as the university couldn't get enough physical surveying instruments for students to keep their social distancing since the purchasing and maintenance cost of physical instruments is often expensive.

The instructors found that the virtual surveying software is simple and easy to use, however, they noticed some limitations with the software, for example some components of the virtual surveying instrument such as screws, knobs, buttons are not designed for students to manipulate, and some details of the virtual instrument operation procedure and interface are missing for students to learn. Students were not able to learn teamwork skills as they couldn't cooperate with the other course mate in a team to carry out the virtual surveying activities together. Besides those minor flaws, mostly they agreed that virtual surveying simulator has enhanced students' interest and their learning efficiency in both surveying course and in physical surveying activities.

They recommended the use of virtual surveying simulator in designing teaching activities as an effective visual teaching aid. Moreover, they suggested that more activities related to field of surveying should be added and at the same time students should be given more time to complete those surveying activities, at least a couple hours more. They would prefer students first learn the physical surveying instrument to carry out the physical activities before learning the operation of the virtual surveying simulator to carry out the virtual surveying activities. Smaller class size is ideal for both physical and virtual surveying lab classes. They all strongly opined that virtual surveying simulator shouldn't replace physical surveying instrument but it can be a complement.

6. Conclusions

It is concluded that the virtual land surveying simulator has shown statistically significant and positive results in stimulating learning interests and enhancing effectiveness for land surveying courses among blended open distance learning (ODL) students at Wawasan Open University (WOU) in the time of Covid-19 pandemic. The virtual surveying simulator alone is not sufficient but it has to be supported with the online learning platform that serves as a one-stop portal for students to access surveying materials, videos, forums, resources etc. It is recommended that the virtual surveying simulator should be added to the surveying field lab using the physical surveying instrument, but never as a substitute to do away with the physical surveying field lab. Time allocated for surveying field lab should be extended for students to complete both physical and virtual surveying activities.

In distance learning setting, it was found that students whom were largely made up of working adults, mature in age, more computer savvy with technology readiness, have certain measures of exposures to surveying experiences at their workplace or have some prior knowledge in surveying by taking land surveying related courses during pre-university study, they were more interested and had positive attitude in surveying, physical surveying instrument and virtual surveying simulators, as p-value < 0.05 (p =<0.001) using paired T-test. Their interests to discover more aspects of surveying were further enhanced with the virtual surveying simulator. Their surveying skills and understanding were reinforced through repeated practices and exercises using surveying simulator after classes.

It will be still a long time before we could return to pre-Covid era and in the meantime, we will be living together with coronavirus in the new normal. Even in a post-Covid world, the landscape of education will never look the same anymore. More future work will focus on the immersive lab learning experiences with the promising use of virtual reality (VR), augmented reality (AR) and artificial intelligence (AI). And the virtual lab simulator could model after unmanned aerial vehicle / unmanned aircraft system (UAV/UAS) or known as drone, which keeps rising as a viable alternative to traditional land surveying. Greater samples size could be collected and more academic years could be monitored to compare the examination scores in the future research.

7. Acknowledgment

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