EFFECTS OF 3D-IMI-VLE ON STUDENT NURSES' KNOWLEDGE, PERFORMANCES, SATISFACTION AND CONFIDENCE: A MIXED METHODS STUDY

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by

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
DG	Dorsogluteal
IIUM	International Islamic Universiti Malaysia
IMI	Intramuscular Injection
IV	Intravenous
LMS	Learning Management Systems
MCQs	Multiple Choice Questions
MMR	Mixed-Method Research
NLN	The National League of Nursing
Online-3D-IMI-VLE	Online Three-Dimensional Intramuscular Injection Virtual Learning Environment
OSCE	Objective Structured Clinical Examination
PBL	Problem Based Learning
QUAL	Qualitative Approach
QUAN	Quantitative Approach
RF	Rectus Femoris
SC	Subcutaneous
SNII	Sciatic Nerve Injection Injury
SNSs	Social Networks Sites
SPSS	Statistical Package for Social Sciences
USM	Universiti Sains Malaysia
VG	Ventrogluteal
VL	Vastus Lateralis
VLE	Virtual Learning Environment
WHO	World Health Organization

LIST OF APPENDICES

KESAN 3D-IMI-VLE TERHADAP PENGETAHUAN, PENCAPAIAN, KEPUASAN DAN KEYAKINAN PELAJAR KEJURURAWATAN: KAJIAN KAEDAH CAMPURAN

ABSTRAK

Persekitaran Pembelajaran Maya (VLE) merupakan pelantar yang menyokong kolaborasi pembelajaran dalam kalangan pelajar yang mengambil bahagian pada masa dan tempat pilihan mereka sendiri melalui jaringan komputer. Pelajar kejururawatan telah diajar suntikan intramuskular (IMI) melalui kaedah pengajaran IMI bersemuka, yang mempunyai banyak kelemahan menurut sorotan literatur dan terdapat keperluan untuk menggunakan teknologi terkini yang sedia ada bagi menyokong pembelajaran. Kajian terbaharu ini bertujuan untuk membina, melaksanakan, dan menilai Sistem Pengurusan Pembelajaran VLE (LMS) yang dinamakan sebagai 3D-IMI-VLE dan menilai keberkesanan 3D-IMI-VLE atas talian dan kaedah pengajaran tradisional IMI dalam kalangan pelajar kejururawatan. Kaedah rekabentuk campuran (urutan terbenam) telah dijalankan dalam dua fasa. Fasa I, kajian eksperimental-quasi, termasuklah penggabunagn peperiksaan OSCE dan MCQ untuk kedua-dua kumpulan, dan data soalselidik ke atas kepuasan dan keyakinan pelajar selepas menggunakan kaedah pendidikan. Dalam fasa I, 30 pelajar daripada setiap universiti (USM dan IIUM) dipilih berdasarkan kriteria kemasukan. Kumpulan eksperimental menggunakan kaedah pengajaran 3D-IMI-VLE secara atas talian, manakala kumpulan kawalan menggunakan kaedah pengajaran IMI secara tradisional atau sedia ada. Fasa II merupakan eksplorasi kualitatif pengalaman pembelajaran pelajar mengenai kajian ini. Temubual mendalam, separuh berstruktur diadakan. Temubual dengan peserta sukarela direkod secara audio dan temubual bertulis dengan kesemua pelajar disalin secara menyeluruh dan dianalisis secara bertema, dengan dibantu oleh ATLAS.ti. Keputusan Fasa I menunjukkan bahawa USM (min = 78.20) sebagai kumpulan

eksperimental jelas mendapat markah lebih tinggi daripada IIUM (min = 58.66) sebagai kumpulan kawalan dalam penemuan OSCE menggunakan senarai semak (p<0.001) dan penarafan global (p<0.001). Manakala,di skor MCQ pula, USM sebagai kumpulan eksperimental (median = 7.0, IQR = 5 di pre-intervensi dan median = 12.5, IQR = 1 di pasca intervensi) mendapat markah lebih tinggi daripada kumpulan kawalan iaitu IIUM (median = 11.0, IQR = 2 di pre intervensi dan median = 11.0, IQR = 2 di pasca intervensi) dengan (p<0.001). Terdapat perbezaan median yang signifikan dalam keyakinan pelajar dalam kumpulan eksperimental (Median = 36.0) dan kumpulan kawalan (Median = 32.0) dengan (p=0.024). Tambahan lagi, skor Kepuasan Pengkomputeran Pengguna Akhir (Median = 52) menunjukkan pelajar sangat berpuashati dengan LMS secara eksperimen. Sewaktu menjelajahi korelasi signifikan di antara skor keyakinan pelajar (r = .376) dan senarai semak OSCE (r = .359) dengan (p=0.003) dan skor penarafan global (p=0.005), keputusan Fasa II menunjukkan bahawa tiga tema wujud daripada data iaitu: 1) Kepuasan pelajar secara menyeluruh 2) Pengalaman pembelajaran 3) Kaedah pembelajaran. Kajian ini mengurangkan keperluan untuk kehadiran fizikal dalam kalangan pelajar, sesi fizikal dalam kalangan pelajar dan pengajar kejururawatan, dan interaksi fizikal pelajar dengan peralatan makmal. Kajian ini mendapati bahawa kaedah 3D-IMI-LE atas talian boleh menggantikan atau menambahbaikan kaedah pengajaran IMI secara tradisi dalam situasi teori dan klinikal. Penemuan kajian ini adalah bernas terhadap adaptasi berkala kurikulum kejururawatan yang termodifikasi, integrase simulasi 3D untuk mempraktikkan kemahiran kejururawatan dan pembinaan LMS.

EFFECTS OF 3D-IMI-VLE ON STUDENT NURSES' KNOWLEDGE, PERFORMANCES, SATISFACTION AND CONFIDENCE: A MIXED METHODS STUDY

ABSTRACT

Virtual Learning Environments (VLE) is a platform that enables collaborative learning among the students who participate at times and places of their own choice through a computer network. Intramuscular injection (IMI) for the nursing students has been taught through the existing IMI teaching method, which has many faults according to the literature, and there is a need to use the available modern technology to support the teaching effectiveness. The current study aimed to develop, implement, and evaluate a VLE Learning Management System (LMS) named as the Online 3D-IMI-VLE and to evaluate the effectiveness of the Online 3D-IMI-VLE and the traditional IMI teaching method among nursing students. A mixed-methods design (Embedded Sequential) was conducted in two phases. Phase I, a quasi-experimental study, included a combination of OSCE and MCQ examination for both groups, and questionnaire data on students' satisfaction and confidence after using the educational methods. In Phase I, 30 students from each university (USM and IIUM) were recruited following the inclusions criteria. The experimental group used the Online 3D-IMI-VLE teaching method, while the control group used the traditional or existing IMI teaching method. Phase II was a qualitative exploration of the student's learning experiences about the study, in-depth, semi-structured interviews were employed. Interviews with selected participants were audio-recorded, and a written interview with all the students was transcribed fully and analysed thematically, assisted by the ATLAS.ti. The results of the Phase I showed that USM as the experimental group (mean = 78.20) significantly outscored IIUM (mean = 58.66) as the control group in OSCE findings by using checklists (p<0.001) and global rating (p<0.001). Meanwhile,

in the MCQ scores, USM as an experimental group (median = 7.0, IQR = 5 in the pre pre-intervention and median = 12.5, IQR = 1 in the post-intervention) significantly outscored IIUM (median = 11.0, IQR = 2 in the pre-intervention and median = 11.0, IQR = 2 in the post-intervention) as the control group (p<0.001). There was a significant median difference of students' confidence between the experimental (Median = 36.0) and the control group (Median = 32.0) with (p=0.024). Also, the End-User Computing Satisfaction score showed the students are highly satisfied (Median = 52) with the experimental LMS. While exploring further a significant correlation between the students' confidence score (r = .376) and the OSCE checklist score (r = .359) with (p=0.003) and the global rating score (p=0.005), the findings of Phase II revealed that three themes emerged from the data: 1) Student' overall satisfaction, 2) learning experience, 3) learning methodology. The current study minimizes the need for the physical presence among the students, physical sessions between students and nurse educators, and physical interaction of the students with the lab equipment. This study found that the Online 3D-IMI-VLE method can replace or added together to the traditional IMI teaching method both in theory and clinical settings. The finding of the current study is suggestive regarding a gradual adaptation of modified nursing curriculums, integration of 3D simulation to practice nursing skills and development of LMS.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Nurses consider being the largest number of health care workers around the world. Their contributions to human health have been increased with time, because of the advancement of nursing science and the existence of reliable, well-educated nurses. Nurses play a significant role in the health and well-being of the communities, with the quality of their education and using evidence-based practice. Also, more evidence supports that the nurse's educational level makes a significant impact on patients' outcome. The levels of patients' mortality can be noticed that it is decreased when many nurses are qualified with a baccalaureate degree. So, proper nursing education and using evidence-based curriculums is essential to maintain and increase communities' health.

In the past, the medical/health field relied on medical doctors only; they used to do all medical/health procedures to the patients with the nurses' assistance. By the time, with many nursing schools open and adapting expand and well-prepared education relied on science, the nurses' role expands to cover most of the patients' daily routine care job. The concept of educational preparations for nurses in the 1950s was based on two years nursing diploma. Later, there was an introduction to a three-years nursing association degree. Lastly, the four years of nursing programs were established in many nursing schools to satisfy this profession's social demand.

In the last two decades, there were a considerable advancement in the nursing education with the existence of modern nursing labs, low and high fidelity mannequins to simulate real-life situations in hospital settings, also the usage of different teaching

methods that relied mostly on the traditional nursing education which based on lecture, lecture-demonstration by the nursing educators and re-demonstrations by the students. This method was reliable at that time and remains till now. But recently, the sum of work of literature of the nursing education founds many faults with using only this teaching method. So, there was a need to adapt to new teaching methodologies. With the advancement of available technology now with laptops, computer, tablets and smartphones, and the significantly increased numbers of nursing students, the education has been shifted to adapt new teaching methodologies such as web-based education, distance education, online education, online 2D or 3D simulations under the umbrella of virtual learning method.

In this study, the main objective is to test one new teaching methods on one most nursing daily practice routine (Intramuscular Injection (IMI)) and to compare the teaching effects of different teaching methodologies (the proposed method using virtual learning environment teaching and the traditional IMI teaching method) on nursing students' cognitive abilities, performances, satisfaction and confidence.

This study compared two groups of nursing students, one group adopted the newly proposed teaching method, and the other group remained using the traditional IMI teaching method. This way may give a clue if we can remain only using the traditional IMI teaching method or replace it with the new teaching method.

The respondents in this study were the year two nursing students from two universities in Malaysia. They were chosen because of the inclusion and exclusion criteria and share the same characteristics the researcher is looking for. More explanation about the respondents available in chapter three.

1.2 Background of the Study

1.2.1 Current practice for Intramuscular Injection (IMI) at University Sains Malaysia (USM) and the International Islamic University Malaysia (IIUM)

Both universities adopted the traditional IMI teaching method, which usually conducted at the one-day classroom with the foundation of the nursing module. Firstly, the settings usually conducted at the nursing lab inside the school, the nurse educator used to review the anatomical positions/sites for all IM muscles using a PowerPoint presentation and review them muscle by muscle. They started with the muscles' landmarks and how to locate the correct position/site of the injection. Usually, the landmarks used to explain are the bone prominent at different positions/sites, then explain other essential aspects of the procedure like a needle to use, depth, layers selection and other nursing practices like Z track or aspiration techniques.

Secondly, the nursing educator demonstrates the procedure in front of the students using the procedure manual trying to follow it step by step so the students can follow him/her. Most of the time, the nursing educator used one or two muscles out of the five muscles. According to the literature, the muscles usually demonstrated are the deltoid and the dorsogluteal muscles only; this is done because of time, large numbers of students, or available resources. Most of the time, the students cannot see or visualize the whole procedure because of the large amounts of students inside the nursing lab.

Thirdly, the nursing educator usually asked one or two students volunteers to do re-demonstration in front of other students. After that, the nursing educators divided the students into small groups and asked them to practice in the lab. At this point, it can be noted that not all students visualized step by step the nursing educator neither

all practices all five muscles neither also they practiced it correctly since the nurse educator cannot monitor all of the students at the same time.

1.2.2 Traditional IMI Teaching Method

The term “traditional teaching” refers mainly to a teaching method that uses lecture notes, memorization, recitation techniques, and textbooks. Transporting education through the conventional approach does not recognize much value in improving problem-solving logical reasoning and decision-making capabilities for the students. Instead, it guides students to accept a non-thinking and data-receiving role (Parasuram et al., 2014).

The lecture considers the central part of the traditional IMI teaching method and the oldest and most widely used one. Lecturing is a direct method to communicate information to students rapidly. While the educator lectures, the nursing students obtain knowledge passively and, afterwards, are tolerated the chance to ask questions at the end of the lectures. In other words, this style of teaching focuses on the content itself rather than on "learners" and the gaps in their qualifications and their learning ability (Mpho, 2018). Nevertheless, stand-alone educators are insufficient to fulfil today's’ nursing students' obligations or prepare them to meet today's professional standards (Jasemi et al., 2018).

Alternatively, the lecture has many advantages that should be acknowledged. The advantages include the opportunity to give knowledge to several students and easily cover a vast volume of content while effectively using class time in a cost-effective manner. But on the other hand, the drawbacks of this conventional nursing teaching are that students are not particularly interested in data collection, interpretation or transfer of experience into reality (Salifu et al., 2019). By utilizing this pedagogy technique, students are viewed as passively processing data as flatulent

containers in which their desires and diverse learning styles are overlooked (An & Carr, 2017). This contrasts with health initiatives such as nursing, emphasizing the need for students to solve challenges, clarify why and bring theory into action (Martyn et al., 2014). Equipping students with essential communication expertise is likewise viewed as essential (Applin et al., 2011), so this is in accordance with the opinions of learning scholars, including Biggs and Tang, and higher order thinking by Bloom (Biggs, 2011).

Besides employing face-to-face lectures, traditional IMI teaching method also using skill demonstrations or lecture-demonstration to teach clinical skills to nursing students. The session typically occurs in a nursing skills laboratory and usually involves demonstrating a skill followed by an opportunity for rehearsal. It is an expectation that further supervised practice undertaken within the clinical environment will consolidate skill acquisition.

In other words, traditional IMI teaching method starts with a lecture to explain pure theory or knowledge. This knowledge must be given before demonstration, e.g., to teach how to deliver IMI, the students bust be educated about the anatomy and physiology to the IMI used muscles, then explaining the procedure itself, followed by a clinical or lab demonstration by the lecturer to teach the students how to deliver IMI correctly. Some of the topics in nursing are pure knowledge, and the other is a mix of knowledge and practice or skill to demonstrate.

It would be appropriate for nursing lecturers or educators to include different teaching strategies to assist in developing the learner's decision-making skills and enhance critical thinking skills. Thus, nurse educators must make use of different teaching methods when facilitating learning. The South African Nursing Council (SANC) (SANC, 2013) specified that the goal of teaching nursing students is to

develop their personal and professional level to become a safe practitioner, knowledgeable, and independent with critical thinking and analytical skills. For clinical education, it mostly has done in laboratories design to simulate real-life situations in hospitals.

The teaching approaches in the nursing skills laboratory are varied and include lectures, lectures with videotapes, and computer-assisted instruction, and then simulation or demonstration. Before the simulation preparation, activities must consist of lectures, textbook readings, and skills practice (Tyerman et al., 2016).

Regardless of the teaching strategy, students are usually allowed time to practice before performing demonstrations of specific clinical skills. Nevertheless, the faculty also lacks the resources to teach essential material, provide opportunities for students to learn and review the success of the clinical skills (Bolwell, 2013). There is little work to assist instructors in choosing the most fitting forms of media and the most efficient training methods for training therapeutic skills, most of which are psychomotor skills required (Baldwin et al., 1991).

The central core of nursing education is to transmit the knowledge and to assist the students in acquiring the required skills and attitudes associated with nursing practice (Salsali, 2005). On the other hand, delivering nursing education through traditional nursing teaching, i.e., the lecture style is blamed for promoting the passive development of information by learners, rather than thinking critically (Alexander et al., 2002).

1.2.3 Virtual Learning Environment (VLE)

A virtual learning environment (VLE) is an umbrella that covers E-learning (EL), Web-Based learning (WBL), distance learning, and online learning. Sometimes these different types of technology names are used interchangeably with the same

meaning. E-learning facilitates schooling through offline or online connectivity through computer technologies (Maphalala & Adigun, 2021). It uses a variety of diverse technologies, such as interactive television, intranets, internet, video, and CD-ROM (Nordstrand, 2017). Meanwhile, WBL is a way of learning, utilizing web-based software or resources in a learning cycle and is comprised of technology that facilitates conventional classroom curriculum and online learning environments. The significance of VLE is it can accommodate the shifting landscape of education and pedagogy.

Previously, VLE adoption and used by different educational institutions, and the participation of the students was slow (Chua & Montalbo, 2014). However, during the last two decades, there has been an apparent attempt to use VLE to assist learning and teaching in advanced education (Walker et al., 2014). The aim of using VLE was to aid, administer, improve and reinforce education, and this was achieved by increasing communication, interactive learning, shifting from pedagogy to andragogy, synchronous and asynchronous telecommunication, global information distribution, and strengthening of knowledge from ongoing interaction (Albrahim, 2020).

Other advantages of using VLE mentioned in the literature include improving the quality of learning outcomes, generating learning environments that do not rely on time or place, increase undergraduate accountability and inspiration for the education progression (Barker & Gossman, 2013). As an online learning system somewhere together, the students and instructors/educators communicate with each other just like the actual classroom but from different geographical places.

In addition, online communication and discussions in the VLE may have different settings and designs, such as student-led versus instructor-led, text-based versus audio or video-based, small-group versus full-scale, and synchronous versus

asynchronous discussions (Trespalacios & Uribe-Florez, 2020). To be successful in the educational process, it is not enough for online course participants to receive only the information available in the literature and electronic sources but obtain assistance and encouragement in the development of instructional material through engaging with the teacher, as well as input on their performance and working methods (Violante & Vezzetti, 2020).

Advances in information technology (IT) have enhanced the development of distance and online learning for health care professionals. The IT era then produces an invention named a virtual learning environment (VLE). It helps achieve a high standard of excellence to provide a continued education that health care practitioners to health care services need. Accordingly, the worldwide creation of teaching methods slowly includes technologies such as digital instructional tools, online schooling, and virtual labs to teach clinical skills (Dearnley et al., 2013). Studies emphasize to use mobile devices to provide and improve the education of clinical knowledge through clinical exercise or practice (Clay, 2011). Indeed, WBL is now much more commonly used in the area of nursing education than conventional teaching styles, owing to the vast number of students and the need to successfully teach functional skills (Traynor et al., 2010).

A VLE declared to be effectively assisting the learning of vast numbers of undergraduates together inside (Lopukhova & Makeeva, 2017) and through organizations (Jesson et al., 2018). Furthermore, the need to update and extend nursing education utilizing emerging technologies has motivated nursing educators to create new instructional methods and to implement new educational models to increase the development of functional skills and hence also the standard of clinical practice (Dearnley et al., 2013). In fact, the technical revolution has changed dramatically the

way people communicate, not least the methods of teaching, changing the way education and training programs are given (Sinclair et al., 2016).

Adding to that, nursing education studies continue to minaret the significance of styling productive clinical education environments for upgrading learner outcomes (Jessee, 2016). Several reports have shown that the amount of time spent by undergraduates in college reduces the amount of time spent in clinical placements and therefore, in the acquisition of professional skills (O'Connor & Andrews, 2015).

According to the National League of Nursing (NLN) (NLN, 2012), the primary skills of the position of academic and clinical nurse instructor include inventing a supportive and productive atmosphere and generating professional success that promotes learning and achieving desired results. Smart apps, for example, may help nursing students develop their medication measurement abilities, which are still viewed as ineffective and unnecessary to maintain patient health (Bagnasco et al., 2016).

On the contrary, the disadvantages of VLE are: 1) limited access to appropriate equipment for students, 2) inadequate and outdated equipment, 3) infrastructure has to be ubiquitous, available and affordable, 4) information can vary in quality and accuracy, 5) students can feel isolated, 6) time wasted in aimless surfing, 7) computer literacy and medical informatics expertise are prerequisites for learning (Sapci & Sapci, 2020).

One of the three-dimensional (3D) application is being used for a while a virtual reality (VR), and it was described as the 21st-century learning aid (Rogers, 2019). A study suggested that students retain more information and apply what they have learned after taking part in VR exercises better (Krokos et al., 2019). Given the potential for improved learning through the use of VR, it is understandable why

researchers, organizations, and educators are now scrutinizing this technology intensively, seeking to add an extra dimension to the classroom in terms of both teaching and learning (Radianti et al., 2020). VR appeared to be mature enough in some areas to be used for teaching procedural, practical knowledge, and declarative knowledge. Fire safety, surgery, nursing, and astronomy were examples of this (Radianti et al., 2020).

The proposed VLE that will be designed and used has two major components, 1) Theory part; the theory part contains two PowerPoints presentations one in English language and another one in bahsa Malayo that explain about intramuscular injection (IMI) and another three videos demonstrating the IMI technique from CDC, 2) Practical 3D part; a 3D course designed to enable the students to practice IMI virtually, which contains five IM muscles that are being used. Also, it enables the students to learn about depth of the inserted needle during the IMI and the angles to be used.

1.2.4 Intramuscular Injection (IMI)

Intramuscular injection (IMI) is a method of giving a drug into a specific muscle. In other words, the drug is deposited inside the muscular tissue fascia under the fatty subcutaneous layer of the skin. The medication then will be absorbed by the muscle tissue and then engaged into the bloodstream quickly. Besides IMI, other routes of injection are via intravenous (IV), subcutaneous (SC) and intradermal (ID). The intramuscular (IM) route is preferred more than the SC way because of the plentiful blood supply inside the muscle and the consistent rise in the bioavailability of medication when injected in IM way (Kilic et al., 2014; Soliman et al., 2018). World Health Organization (WHO) (WHO, 2016b) reported that around 16 billion injection applications were made each year, and 90 % of these injections were used for treatment

purposes. Nonetheless, WHO notes that safety precautions have usually not been taken in many countries while giving the injection.

As for comparison among the three types of injection, the absorption of IMI is slower than IV injections but faster than SC and ID injections. Also, when IMI is given in a higher dosage form, it may cause a high discomfort effect inside the deep muscle tissue (Hunter, 2008). It can also cause infection, pain, necrosis, abscess hematoma, nerve injury ecchymosis, vascular and periostitis if IM injection is given in a wrong way (Gülnar & Çalışkan, 2014; Kaya et al., 2015). Thus, although IMI is seemed to be an easy practice, it must be administered with extra caution using the correct administration method (Boyd et al., 2013). Regarding this, different literature highlighted health professionals to acquire the essential information and experience about IM administrations to prevent and reduce these complications (Cocoman & Murray, 2008).

The method of administering injections of IM had improved in the last few decades based on evidence from research related to the developments of the available equipment for the technique as recommended by the Centres for Disease Control and Prevention (CDC, 2020). For instance, they used glass syringes that need to be boiled with hot water to disinfect the syringes before use has changed to the disposable syringes and needles. In fact, with the availability of the new materials, double needles are used when giving the IMI whereby one needle is used to aspirate the medication, and another needle is used to inject the medicine.

As mentioned earlier, IM injections should be completed cautiously to evade difficulties. Medication administration via injections is considered a vital skill for nursing students, including various ways of knowledge application, problem-solving, decision making, and critical thinking. Further to that, nurses are required to

understand the chemical compositions of the drugs and the relevant nursing actions needed, e.g., the 8 ‘Rights’ - right patient, medication, reason, dose, route, time, response, and documentation (Kavanaugh, 2016). The WHO (2016b) described injections as one of the most common procedures in health care, and hazardous injection performs are related to radical morbidity and mortality.

As mentioned, medicinal products delivered via IM injection are absorbed more quickly by muscle fibres than through the subcutaneous route (Malkin, 2008). Thus, the IM location is used for medicines that need a rapid absorption rate but also a rationally long action (Rodger & King, 2000). Due to their plentiful bloodstream, IM injection sites can captivate more substantial amounts of drugs, such as hormonal therapies, anti-emetics, sedatives, painkillers, and vaccinations, which can be injected by IM way in public and acute care setting (Ogston-Tuck, 2014). This type of injection is considered to be an invasive procedure, and it is ordered in high regularity. Therefore, reaching minimum safety values is authoritative as a means of shielding against the preventable spread of disease or injuries.

The IM locations selection depend on the age and illness of the patient and the capacity and type of injected drugs (Lynn, 2018). Positions or locations for IMI include the dorsogluteal muscle, ventrogluteal muscle, vastus lateralis muscle, rectus femoris, and the deltoid muscle. Choosing the injection site sometimes depends on familiarity and confidence rather than on “best practice” (Ogston-Tuck, 2014). Regarding ventrogluteal, there is an adequate indication that the ventrogluteal considered the most-likely location each time and is a satisfactory location for oily and infuriating medicines. However, the ventrogluteal site has a limited number of blood vessels and nerves but has the most significant muscle depth compared to other sites (Ogston-Tuck, 2014).

When selecting a needle size, the quantity of adipose tissue, the Body Mass Index (BMI) of the patient, medication viscosity, age, and injection locations all affects the needle selection (Hunter, 2008). A lengthier needle with a bigger gauge is vital to infiltrate deep muscle tissue. The needle is injected into at a 90^{o} angle vertical to the muscle or at as nearly a 90o angle as can using a fast, darting motion when inserting the needle.

A primary concern of IMI is that if it is not being administered correctly, it leads to related complications. The complications with IMI include pain, muscle atrophy, cellulitis injury to the bone, nerve injury, and sterile abscesses (Hunter, 2008). The most dangerous complication of IMI is if the needle accidentally injected the nerve causing sciatic nerve injury (SNI). Thus, IMI into the buttock (i.e., dorsogluteal site) is considered overwhelming. In extreme cases, the hamstrings muscles and all the muscles below the knee are paralyzed.

As this IMI procedure is associated with many patients' complications, discomfort, and painful experiences, each health care institution must have best practice guidelines for drug administration in IMI. With this, it is fair to expect nurses in clinical practice to implement the new recommendations (Šakić et al., 2012).

1.3 Problem Statement and Justification of the Study

To answer why this study had been conducted, it is important to understand the gaps that the traditional IMI teaching have and the solutions for it. Regarding this, a literature review search has been done to search for traditional IMI teaching method advantages and disadvantages and how it could be improved, and a Focus Group Discussion (FGD) was conducted to highlight all important points about it.

a) Literature Review of the problems/gabs

Traditional IMI teaching method includes lecture-demonstrations and practices the skills on non-interactive models. The learning has usually been done to a large group of nursing students around 30-50 students in the nursing skills laboratory. This conventional teaching form centred on lectures does not require lecturers to recognize the differences in student learning abilities, e.g., some students learn more using visual, and others learn using auditory. In contrast, some others only learn by doing (kinetics learning). Besides, many students who cannot keep up with the course's pace will become inattentive lectures in the classroom and less inspired to learn (Shang & Liu, 2018).

Generally, there were many criticisms about traditional learning (Hong & Yu, 2017). With a substantial number of students in the class, a huge volume of knowledge is transmitted in a limited period without interacting efficiently with the teachers. Students believed that they were not adequately exposed to clinical learning opportunities because a large number of students were put in a public, academic hospital, which offers clinical training for a range of students (Motsaanaka et al., 2020).

This contributed to overcrowding and created challenges for student nurses in meeting their clinical goals and poor theory integration into practice. Later, inadequate opportunities for clinical learning led to an extension of the training of student nurses. Therefore, student nurses are not embedded in the nursing profession (Motsaanaka et al., 2020).

In the traditional nursing education, the education is implemented in the form of psychomotor skills, the use of demonstration method in theoretical education, applications on mannequins and models in laboratory and application of skills for real patients in the clinical environment (Tuzer et al., 2016). However, students can feel

stress and anxiety because of a lack of experience, lack of familiarity in dealing with mannequins training and supplies, increased knowledge of professional errors, and afraid of making professional errors (Ross & Carney, 2017). The traditional form of instruction is primarily lecture, which would be simple and focuses solely on the teaching results but ignores the teaching effects (Yue et al., 2019).

According to Sowan and Idhail (2014), major faults of the lecture-demonstrations and practices the skills on non-interactive models included (1) students' incapacity to comprehend procedures as a whole as they are seen to be scattered and delayed phases, (2) the program's failure to promote a seamless transfer to hospital environments, and (3) insufficient laboratory room and packed curriculum hinder and student's operation (Sowan & Idhail, 2014). Because of this, the method of teaching IMI seems to be disadvantaged or affected both the nurse educators and the nursing students' performances. Nurse educators strive to pursue innovative training approaches, such as scenario modelling and high-fidelity digital instruction in the face of the complexity of traditional nursing education (Powell, 2020).

The nursing students make a tiny effort in satisfying their didactic desires (Gholami et al., 2016). In additions to the above faults, as shown in one particular study, traditional teaching could not encourage undergraduates' critical thinking (Gholami et al., 2016). Moreover, traditional teaching delivers undergraduates with partial chance to energetically be involved in group discussions, classroom actions, and data analysis and use the scholarly information in practice (Dehghanzadeh & Jafaraghaee, 2018).

The student's satisfaction plays an essential role in nursing students' learning experiences and affects their academic achievements. Satisfaction and self-confidence in traditional learning are essential since they need to be satisfied with their undertaken

educational methods. Traditional teaching and training approaches encourage student satisfaction and self-confidence in learning (Costa et al., 2020). However, one study conducted in Iran by Hakim (2014), found that students had little satisfaction concerning the clinical environment, and the theoretical educational method by professors while using traditional nursing teaching. Researchers believe that clinical educators significantly influence clinical training excellence and can offer good clinical experiences to the students (Hakim, 2014).

Because of these education limitations, it indicated a need to replace/supplement the conventional lecture-demonstration approach by more immersive online digital educational tools (Sowan & Idhail, 2014) so that the teaching of IMI is more effective. Richardson et al. (2013) suggested that a VLE was found to be effective compared to the traditional method as it would resemble nursing realities.

The administration process is difficult when examining the intramuscular drug, which requires many procedures when the addition to the puncture method itself. Flexible technical tools to help educate nursing practitioners are needed to prevent hazards connected with IMI's mistaken results. Nursing education requires nursing students to learn the necessary clinical skills to fulfil their purpose as nurses (Xu et al., 2019). However, the traditional nursing teaching method is insufficient to fulfil this criterion (Oyelana et al., 2018).

b) Focus Group Discussion

The Focus Group Discussion (FGD) was conducted to obtain nurse educators' expert opinions about traditional IMI teaching method they have been practising so far. The focus group discussion was conducted in a small discussion room situated in the Nursing Skills Laboratory of School of Health Sciences of Universiti Sains

Malaysia. Participants of the focus group consisted of six senior nurse educators involved in teaching and supervising IMI to the diploma and undergraduate nursing students in the institution. Open-ended questions were set and validated before the focus group discussion to discuss the traditional IMI teaching method and the new teaching method using computer software.

The objectives of the focus group discussion were as follows:

- To understand how the nurse educators perceive the nursing students' competencies in giving an IMI taught using traditional IMI teaching method.
- To understand how nurse educators perceive the proposed teaching method using computer software in the virtual learning environment (VLE) to teach IMI among nursing students.

Generally, the focus group participants stated that the traditional IMI teaching method is more of a teacher rather than student-centred. In other words, lecture-demonstrations offers one-way communication and less interactive learning. According to the participants, it was also challenging to control a big group of about 40 nursing students to focus on the lecture-demonstration. Another issue raised by the focus group participants was the difficulty faced by the nurse educators and the nursing students to perform each step the same as was demonstrated during the lecture-demonstration.

The participants also observed that the nursing students were still lacking in mastering the techniques of handling the injection syringe correctly and firmly to give the intramuscular injection as frequently observed during OSCE and in the clinical areas. One another note, the participants found that when using non-interactive mannequins to practice, the nursing students always faced with difficulty in feeling the correct injection site and location of the sciatic nerve in the dorsogluteal site.

Regarding student's self-practice in their free time, even though they were being provided with the checklist of IMI procedure and guidance from the nurse in charge of the nursing skills laboratory, the nursing students often observe to come for self-practice only around the examination time. This is due to their tight teaching and learning schedules in the undergraduate nursing program. It seems that there is no official record about how long they took to practice in the lab.

Also, the focus group participants were triggered with questions related to using VLE for the nursing students to learn about the intramuscular injection. In this regard, the focus group participants' general responses seemed to approve that the VLE would improve the teaching method on IMI since the simulation is close to reality and thus could assist the nursing students in getting a clearer picture of what is taught to them.

Participants reported any negative overcrowding experiences. They noted that nursing educators have difficulty managing large numbers of students practising in the same place (lab or hospital settings) and students compete for clinical procedures. A negative experience of hospital students overcrowding resulted in fewer clinical learning opportunities (Motsaanaka et al., 2020).

It could also provide consistent information on giving an IMI to the nursing students compared to the lecture-demonstration because it is always ready in the online computer software. In this way, the focus group highlighted the principle of flexibility in learning, which would be applied when using the software. The focus group also suggested that there must be an activity to monitor the nursing students' participation in the practical session via the software, the software must have a feature that enables the course coordinator to follow and monitor students practice time and if they practice

or no, how long the logged in to the program and a test at the end of the class to check program efficacies.

According to the focus group, rather than using a one-way communication, the software could provide a platform to allow nursing students to share information or give feedback on their performance. The focus group preferred that the software that will be produced should apply the concept of interactive learning to enhance learning the intramuscular injection skills. Ideally, the graphic should have a three-dimension so that the injection sites anatomical part could be seen from skin layers.

The focus group suggested the computer software should allow the nursing students to virtually handle the syringe, locate the correct injection site, and feel the patient's soft skin to give the dose. Another recommendation by the focus group participants is to ensure the software could have two-way communication between the nursing student and the nurse educator.

Finally, the focus group participants accepted the idea of using the online computer software as a tool to provide opportunities for the nursing students to learn intramuscular injection by an interactive, flexible, and virtual learning way. The focus group participants also suggested that the software go through validity and reliability processes before it could be officially used for the nursing students and added to the nursing curriculum.

1.4 Objectives of the Study

1.4.1 General Objective

To create the Online 3D-IMI-VLE and to evaluate the effectiveness of the Online 3D-IMI-VLE and traditional IMI teaching method among nursing students.

1.4.2 Specific Objectives

1. To compare the IMI performance by evaluating the mean score of the OSCE checklist between the Online 3D-IMI-VLE and the traditional IMI teaching method.
2. To compare the IMI performance by evaluating the mean score of OSCE global rating between the Online 3D-IMI-VLE and the traditional IMI teaching method.
3. To compare the IMI knowledge by evaluating the mean score of MCQ between the Online 3D-IMI-VLE and the traditional IMI teaching method.
4. To compare the students' satisfaction by evaluating the mean score of the satisfaction domain of the Student Satisfaction and Self-Confidence in Learning Scale between the Online 3D-IMI-VLE and the traditional IMI teaching method.
5. To compare the students' confidence by evaluating the mean score of the self-confidence domain of the Student Satisfaction and Self-Confidence in Learning Scale between the Online 3D-IMI-VLE and the traditional IMI teaching method.
6. To determine the computing satisfaction by evaluating the mean score of the end-user computing satisfaction for using the Online 3D-IMI-VLE teaching method.
7. To determine the association between the students' satisfaction and IMI performance (OSCE checklist) for the Online 3D-IMI-VLE and the traditional IMI teaching method.

8. To determine the association between the students' satisfaction and IMI performance (OSCE global rating) for the Online 3D-IMI-VLE and the traditional IMI teaching method.
9. To determine the association between the students' confidence and IMI performance (OSCE checklist) for the Online 3D-IMI-VLE and the traditional IMI teaching method.
10. To determine the association between the students' confidence and IMI performance (OSCE global rating) for the Online 3D-IMI-VLE and the traditional IMI teaching method.
11. To explore the students' learning experiences after using the Online 3D-IMI-VLE and the traditional IMI teaching method.

1.5 Research Questions

1. Is there any significant difference in the IMI performance by evaluating the mean score of the OSCE checklist between the Online 3D-IMI-VLE and the traditional IMI teaching method?
2. Is there any significant difference in the IMI performance by evaluating the mean score of the OSCE global rating between the Online 3D-IMI-VLE and the traditional IMI teaching method?
3. Is there any significant difference in the IMI knowledge by evaluating the mean score of the MCQ between the Online 3D-IMI-VLE and the traditional IMI teaching method?
4. Is there any significant difference in the students' satisfaction by evaluating the mean score of the satisfaction domain of Student Satisfaction and Self-

Confidence in Learning Scale between the Online 3D-IMI-VLE and the traditional IMI teaching method?

5. Is there any significant difference in the students' confidence by evaluating the mean score of the self-confidence domain of Student Satisfaction and Self-Confidence in Learning Scale between the Online 3D-IMI-VLE and the traditional IMI teaching method?
6. What is the level of computing satisfaction by evaluating the mean score of the end-user computing satisfaction for using the Online 3D-IMI-VLE teaching method?
7. Is there any association between the students' satisfaction and IMI performance (OSCE checklist) for the Online 3D-IMI-VLE and the traditional IMI teaching method?
8. Is there any association between the students' satisfaction and IMI performance (OSCE global rating) for the Online 3D-IMI-VLE and the traditional IMI teaching method?
9. Is there any association between the students' confidence and IMI performance (OSCE checklist) for the Online 3D-IMI-VLE and the traditional IMI teaching method?
10. Is there any association between the students' confidence and IMI performance (OSCE global rating) for the Online 3D-IMI-VLE and the traditional IMI teaching method?
11. What are the students' learning experiences after using the Online 3D-IMI-VLE and the traditional IMI teaching method?

1.6 Null Hypothesis

1. There is no significant difference in the IMI performance by evaluating the mean score of the OSCE checklist between the Online 3D-IMI-VLE and the traditional IMI teaching method.
2. There is no significant difference in the IMI performance by evaluating the mean score of the OSCE global rating between the Online 3D-IMI-VLE and the traditional IMI teaching method.
3. There is no significant difference in the IMI knowledge by evaluating the mean score of the MCQ between the Online 3D-IMI-VLE and the traditional IMI teaching method.
4. There is no significant difference in the students' satisfaction by evaluating the mean score of the satisfaction component of Student Satisfaction and Self-Confidence in Learning Scale between the Online 3D-IMI-VLE and the traditional IMI teaching method.
5. There is no significant difference in the students' confidence by evaluating the mean score of the self-confidence component of Student Satisfaction and Self-Confidence in Learning Scale between the Online 3D-IMI-VLE and the traditional IMI teaching method.
6. There is no association between the students' satisfaction and IMI performance (OSCE checklist) for the Online 3D-IMI-VLE and the traditional IMI teaching method.
7. There is no association between the students' satisfaction and IMI performance (OSCE global rating) for the Online 3D-IMI-VLE and the traditional IMI teaching method.

8. There is no association between the students' confidence and IMI performance (OSCE checklist) for the Online 3D-IMI-VLE and the traditional IMI teaching method.
9. There is no association between the students' confidence and IMI performance (OSCE global rating) for the Online 3D-IMI-VLE and the traditional IMI teaching method.

1.7 Operational Definitions

1. Online 3D-IMI-VLE

   It refers to an online 3D educational program to teach the IMI technique to the undergraduate nursing students using a virtual learning environment. It contains a theory module and a 3D simulation module. The theory module contains PowerPoint presentations and video demonstrations. The 3D simulation module contains a virtual clinic simulation of a patient and a nurse. It allows practising IMI technique on the five different injection sites.

2. Traditional Intramuscular Injection (IMI) teaching method

   It refers to the traditional teaching method, where the nursing student attends a PowerPoint presentation by the nurse educator in a lab setting, followed by IMI technique-demonstrations by the nurse educator. Return demonstration by the students, and self-practice on the lab mannequin on the same day at a single instance, then the students can practice by themselves in the lab according to the time available and their willingness to practice.

3. Intramuscular Injection (IMI) performance