THE DESIGN, DEVELOPMENT AND VALIDATION OF WORK-BASED SURFACE ANATOMY TEACHING (WSAT) MODEL AND ITS EFFICACY ON STUDENTS' LEARNING COMPETENCIES

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UNIVERSITI SAINS MALAYSIA

2024

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by

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Thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

May 2024

ACKNOWLEDGEMENT

Praise to Allah, the most compassionate and most merciful, whose blessing has helped me through the entire completion of this PhD thesis. I would like to express my deepest gratitude and appreciation to all those who have contributed to the completion of this thesis. Without their support, guidance, and encouragement, this research endeavour would not have been possible. First and foremost, I am immensely grateful to my main supervisor, Associate Professor Dr Siti Nurma Hanim Hadie @ Haji, for her invaluable guidance, patience, and unwavering support throughout this entire journey. Her expertise, constructive feedback, and insightful suggestions has greatly shaped the outcome of this work. I extend my heartfelt thanks to my co-supervisors, Associate Professor Dr Muhamad Saiful Bahri Yusoff, Dr Fazlina Kasim and Professor Dr Asma' Hassan for their great support, advice and contribution for the research and completion of this thesis. I am grateful to Universiti Sains Malaysia for providing the necessary resources and providing research grants (1001/PPSP/8016120) to support this project that have been instrumental in conducting this research. I also would like to express my sincere appreciation to my family for their unwavering support, love, and encouragement throughout my academic journey. I extend my gratitude to my friends and colleagues who have provided valuable insights, engaging discussions, and moral support during this research process. Their encouragement and belief in my capabilities have been a constant source of motivation. Lastly, I would like to thank all the participants who volunteered their time and contributed their perspectives to this study. Their willingness to share their experiences and insights has been invaluable in shaping the findings of this research.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
ATLAS.ti	Archiv für Technik, Lebenswelt und Alltagssprache (Archive for Technology, Lifeworld and Everyday Language.text interpretation)
BESS	Burch engagement survey for student
CA	California
CE	Cognitive engagement
CI	Confidence interval
CLS	Cognitive load scale
CLT	Cognitive load theory
Corp.	Corporation
CVI	Content validity indices
df	Degree of freedom
ECG	Electrocardiogram
EE	Emotional engagement
EL	Extraneous load
e-learning	Electronic learning
FVI	Face validity index
GmbH	Gesellschaft mit beschränkter Haftung
IQR	Interquartile range
ICC	Intraclass Correlation coefficient
IL	Intrinsic load
Inc	Incorporation
I-CVI	Item-level content validity index
I-FVI	Item-level face validity index
MCQ	Multiple choice question
MD	Mean difference
MESH	Medical Subject Headings
MQA	Malaysian Qualification Agency
MTFQ	Multiple true false question
MUET	Malaysian University English Test
NY	New York
PBL	Problem-based learning

PBQ	Problem-based question
PhD	Doctor of Philosophy
PRISMA	Preferred Reporting Items for Systematic and Meta-Analyses Reviews
PRISMA-ScR	Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Review
OBA	One best answer
RCT	Randomised controlled trial
SBA	Single best answer
SBQ	Scenario-based question
SD	Standard deviation
SP	Standardised patient
SPL	Self-perceived learning
SPSS	Statistical Package for the Social Sciences
S-CVI	Scale-level content validity index
S-CVI/UA	Scale-level content validity index universal agreement
S-CVI/Ave	Scale-level content validity index averaging method
S-FVI	Scale-level face validity index
S-FVI/UA	Scale-level face validity index, universal agreement
S-FVI /Ave	Scale-level face validity index, averaging method
UKM	Universiti Kebangsaan Malaysia
UM	University of Malaya
UMS	Universiti Malaysia Sabah
UniSZA	Universiti Sultan Zainal Abidin
UPM	Universiti Putra Malaysia
USA	United States of America
USM	Universiti Sains Malaysia
VR	Virtual learning
WA	Washington
WSAT	Work-based Surface Anatomy Teaching
WoS	Web of Science

LIST OF APPENDICES

REKABENTUK, PEMBANGUNAN DAN PENGESAHAN MODEL PENGAJARAN ANATOMI PERMUKAAN BERASASKAN KERJA (WSAT) DAN KEBERKESAN TERHADAP KOMPETENSI PEMBELAJARAN PELAJAR-PELAJAR

ABSTRAK

Anatomi permukaan adalah salah satu cabang anatomi yang dapat membantu pelajar perubatan mempelajari dan menjalankan pemeriksaan fizikal dan prosedur klinikal secara selamat. Walau bagaimanapun, pendidikan anatomi permukaan kurang ditekankan dalam kurikulum perubatan, dan bukti empirikal adalah tidak mencukupi untuk menyokong keberkesanan pengajaran anatomi permukaan dalam pendidikan tinggi. Matlamat kajian ini adalah untuk mewujudkan model pengajaran anatomi permukaan berasaskan kerja yang sah dan berkesan berdasarkan dapatan tinjauan skop. Kesahan kandungan, proses tindak balas, dan kesahan struktur dalaman model Pengajaran Anatomi Permukaan Berasaskan Kerja (WSAT) telah dijalankan melalui penilaian pakar. Ujikaji rawak secara terkawal berskala kecil melibatkan 28 peserta telah dijalankan. Kumpulan kawalan menerima pengajaran anatomi permukaan rutin, manakala kumpulan intervensi menerima pengajaran WSAT. Penilaian sebelum dan selepas pengajaran, serta penulisan refleksi dan sesi susulan, digunakan untuk menilai pengekalan pengetahuan dan perubahan kecekapan pembelajaran. Berbanding dengan kumpulan kawalan, kumpulan intervensi menunjukkan beban kognitif extraneous yang jauh lebih rendah, persepsi pembelajaran kendiri yang lebih tinggi, dan penglibatan kognitif dan fizikal yang lebih baik. Walaupun mempunyai kompetensi asas anatomi permukaan yang sama, kumpulan intervensi mengatasi kumpulan kawalan dalam pemerolehan kompetensi kognitif, psikomotor dan afektif, serta

pengekalan kemahiran psikomotor dan tingkah laku profesional. Pengalaman pelajar yang positif semasa pengajaran WSAT didedahkan melalui analisis kualitatif. Walaupun model WSAT menghasilkan keputusan yang positif, kesan pengajaran terhadap tingkah laku pelajar dan organisasi perlu dinilai pada masa hadapan. Secara ringkasnya, pengajaran anatomi permukaan di tempat kerja boleh berjaya dengan menggunakan model dan kerangka kerja WSAT yang berdasarkan bukti. Sambil mengakui kelemahan kajian dan keperluan untuk ujian terkawal rawak (RCT) yang lebih besar pada masa depan, pendidik masih perlu mempertimbangkan untuk memasukkan model WSAT ke dalam amalan pengajaran mereka. Terlibat dalam aktiviti sedemikian dapat meningkatkan pemahaman pelajar tentang anatomi dan mendorong penglibatan yang lebih besar dalam pembelajaran anatomi permukaan.

THE DESIGN, DEVELOPMENT AND VALIDATION OF WORK-BASED SURFACE ANATOMY TEACHING (WSAT) MODEL AND ITS EFFICACY ON STUDENTS' LEARNING COMPETENCIES

ABSTRACT

Surface anatomy is a subdiscipline of anatomy that helps medical students to learn and perform physical examination and clinical procedures safely. However, surface anatomy education is less emphasised in the medical curricula, and there is insufficient empirical evidence to support the effectiveness of surface anatomy teaching in higher education. The goal of this study is to create a valid and effective work-based surface anatomy teaching model based on two scoping review findings. The content, response process, and internal validity of the Work-based Surface Anatomy Teaching (WSAT) model were established through expert ratings. A small-scale randomised-controlled trial with 28 participants was carried out. The control group received routine surface anatomy instruction, whereas the intervention group received the WSAT instruction. Pre- and post-teaching assessments, as well as reflective writing and follow-up sessions, were used to assess knowledge retention and learning competencies change. In comparison to the control group, the intervention group demonstrated significantly lower extraneous load, higher self-perceived learning, and higher cognitive and physical engagement. Despite having similar baseline surface competencies, the intervention group outperformed the control group in cognitive, psychomotor, and affective competency acquisition, as well as retention of psychomotor skills and professional behaviour. Positive student experiences with the WSAT instruction were revealed through qualitative analysis. While the WSAT model produced positive results, the impact of the instruction on students' behaviours

and organisation should be assessed in future studies. In essence, teaching surface anatomy in a workplace setting can be successful by utilizing the evidence-based WSAT model and framework. While acknowledging the study's limitations and the need for future larger randomised controlled trials (RCTs), educators should still consider incorporating the WSAT model into their teaching practises. Engaging in such activities can improve students' comprehension of anatomy and foster greater engagement in surface anatomy learning.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter elaborates the background, problem statement and significance of the study; and outlines the research questions, objectives and hypothesis. The present study attempted to design and develop a teaching model that is grounded by the principles of effective work-based and surface anatomy teaching.

This study was divided into three phases: (1) Phase 1: The design and development of the work-based surface anatomy teaching (WSAT) model; (2) Phase 2: Validation of the WSAT model; (3) Phase 3: Intervention stage to evaluate the impact of the WSAT model on the students' learning competencies. In general, the aim of Phase 1 is to develop the WSAT model based on the theoretical and conceptual frameworks of effective strategies in work-based and surface anatomy teaching. The elements of effective strategies for work-based and surface anatomy teaching were generated from two scoping reviews. In Phase 2, two validity studies, namely content and response process validity, were conducted to evaluate the validity of the WSAT model. Additionally, the internal structure of the model was also investigated to determine the stability of its construct. In Phase 3, an experimental study was executed to investigate the impact of the WSAT model on students learning performance, through quantitative and qualitative research approaches.

1.2 Background of the study

Surface anatomy can be conceptualised as the knowledge that deals with external features of human body. It can be divided into two sub-components, namely, palpable anatomy (i.e., refers to knowledge of anatomical structures that can be located via palpation) and projectional surface anatomy (i.e., refers to knowledge that deals with the surface projection of unpalpable deeper body structures) (Hale et al., 2010b; Koch et al., 2016; Mirjalili et al., 2012). Surface anatomy is considered as one of the essential components in anatomy and medical education (Sugand et al., 2010), as it is a prerequisite for the development of clinical skills competency (Azer, 2013; Hale et al., 2010b).

Mastering the concept of surface anatomy is important for preclinical year medical students before progressing into the clinical phase of medical curriculum (Leveritt et al., 2016). Medical students and graduates who are competent in surface anatomy knowledge and skills would be able to locate bony and soft tissue body landmarks, demonstrate precise clinical examination, practice procedural skills and interpret imaging investigation (Asad & Nasir, 2015). Due to the importance of surface anatomy knowledge, the method of surface anatomy teaching has gradually evolved to accommodate the demands from stakeholders on safe clinical practice (Leung et al., 2006).

In the early 20th century, the surface anatomy instruction has been initiated and was published as self-learning resources due to the demand from the stakeholders (Moorhead, 1905). In the 1930s, the surface anatomy teaching evolved further with the use of living models in demonstration of surface markings to complement the cadaveric-based pedagogy (Waterston, 1931). Three decades later, Barrows et al., (1968) reported the use of hands-on activities on living models in surface anatomy laboratories, which received positive feedback from the students and anatomists. Given the increasing demand for clinical applied knowledge in modern integrated curriculum, the use of living models in surface anatomy education has been integrated with clinical application (Stillman et al., 1978). Henceforth, various teaching strategies have been utilised to incorporate the clinical component into surface anatomy teaching, which include clinical applied peer group model (Metcalf et al., 1982), clinical oriented radiological anatomy teaching (Pabst et al., 1986), and integration of basic clinical skills in anatomy instruction (Monkhouse, 1992).

In a broad sense, integration of surface anatomy knowledge can happen horizontally (i.e. integration of surface anatomy with gross anatomy knowledge), and vertically (i.e., integration of surface anatomy with clinical knowledge). Having said that, vertical integration of surface anatomy knowledge plays a more important role in integrated medical curriculum as this form of integration facilitated students' learning (Gulnaz et al., 2018). Furthermore, the clinical elements in surface anatomy skills promote experiential learning and as a result, enable learners to value professional behaviour and enhance their confidence in clinical practice (Yammine, 2014). Therefore, to produce a competent medical practitioner, a strategy of combining experience-based teaching modality with basic medical sciences element is utmost important (Hoffman et al 2019).

To acquire surface anatomy skills, teaching would be more effective when it is conducted in a clinical environment with proper supervision (Stabile, 2015). The early exposure to the clinical learning environment is a form of horizontal and vertical integration, whereby the surface anatomy knowledge is integrated with gross anatomy and clinical knowledge respectively, with emphasis on the hands-on activities (Smith et al., 2014). This integration could be done by teaching surface anatomy in an authentic or high-fidelity simulated environment using real patients in wards and clinics. Since work-based teaching has been proven to enhance knowledge retention (Eraut 2012), combining work-based teaching with surface anatomy elements can be deemed effective when it is properly designed and delivered.

Medical students have benefited from early clinical exposure, which has been proven to improve their cognitive, psychomotor and affective learning (Shigli et al., 2017). During the clinical phase of medical training, medical students have limited opportunities and time for anatomy revision because of the increased demand to learn about diseases, diagnosis and management of clinical cases. Contrarily, preclinical medical students have limited opportunity to apply the learned anatomy knowledge in clinical setting. Therefore, teaching surface anatomy to preclinical medical students in work-based environment would allow them to enhance their cognitive ability in understanding the basic gross anatomy and applying it in clinical relevant context; psychomotor ability by showcasing their skills in identifying the surface anatomy landmarks; and affective skills, through their interactions with patients, colleagues and other inter-professional health personnel. This form of innovative teaching strategy could also address complex logistical and financial issues that are faced by modern anatomy education. Although the advantages of some anatomy teaching methodologies have been revealed by researchers, there is scarcity of evidence on the implementation of the work-based teaching in surface anatomy context. Therefore, it is crucial to develop an evidence-based and valid teaching model pertaining to the work-based surface anatomy.

1.3 Problem statement

Despite the well-documented evidence of the importance of surface anatomy to clinical practice (Jayasekera et al., 2005; Roche et al., 2009), there is lack of emphasis on surface anatomy in anatomy curriculum or syllabus (Yammine 2014; Leveritt et al., 2016). In contrast to other subdisciplines of anatomy—gross anatomy, neuroanatomy, histology and embryology—which are normally given specific slots in the academic schedule, surface anatomy content is frequently embedded in a related gross anatomy topic as one small learning outcome. Consequently, students are either taught didactically on the surface anatomy or are required to learn the content on their own without any guidance (Stabile, 2015). Indeed, Azer, (2013) revealed that surface anatomy content occupies not more than 4% of the content in standard gross anatomy textbooks. In a study conducted among medical students and graduates in the United Kingdom, the subjects perceived that lack of surface anatomy competency is an area of concern, therefore the researchers suggested that more effort should be dedicated to clinical applied surface anatomy during preclinical phase of medical education (Leveritt et al., 2016). Moreover, with reduced feasibility of cadaveric dissection due to various limitations in the medical curriculum (Yammine, 2014), students could no longer learn surface anatomy through direct observation and hands-on palpation of anatomical landmarks on the cadavers (Kotze et al., 2012). As a result, surface anatomy is learned using various tools that are less cost effective, such as body painting, living anatomy model, real-time ultrasound and virtual human dissector (Azer, 2013; Kotze et al., 2012).

At the end of the 20th century, medical curricula were transformed from traditional, discipline-based approach to integrated approach in most part of the world (Kai-Kuen Leung et al., 2006; Gwee et al., 2010; Johnson et al., 2012). The medical education revamp has caused a toll to anatomy education as there was reduction in time and resources dedicated to anatomy (Monkhouse, 1992; Dangerfield et al., 2000; Wong and Tay, 2005; Turner, 2007; Bergman et al., 2013; Estai and Bunt, 2016). As a result, further adaptations were introduced in anatomy teaching, such as the adoption of problem-based learning, use of prosected specimens and models over dissection, and application of radiographic images and simulations (Kai-Kuen Leung et al., 2006). Furthermore, rapid evolution of technology has led to the emergence of new teaching tools in surface anatomy, such as multimedia imaging (Żurada et al., 2011) and virtual anatomy software (Asad and Nasir, 2015). Despite the advantages of technology-enhanced method, there is increasing concern among anatomists that these methods would replace the kinaesthetic learning elements on the direct real human body (Hale et al., 2010). In a nutshell, the dramatic transformation of medical education with the ineffective adaption from anatomists has contributed to the ineffective surface anatomy education.

Surface anatomy connects theory and practise in medical disciplines, hence is critical for clinicians (Standring, 2012). Standring (2012) stated that the ability to locate structures beneath the skin using palpable landmarks is essential, whereby surgeons use surface landmarks to precisely place incisions. The underrated surface anatomy knowledge and skills among medical students have been linked to weak procedural skills, and thus, resulting in unsafe clinical practice (Estai and Bunt, 2016). Concerns have been raised among anatomists over the substandard surface anatomy education in medical and allied health sciences programs (Johnson et al., 2012; Yadegari and Hosseini-Sharifabad, 2012; Yammine, 2014; Leveritt et al., 2016), which consequently affect the clinical competency of future doctors and healthcare practitioners (Jeyasekera et al., 2005; Roche et al., 2009; Yammine, 2014). Indeed, it was documented that inadequate surface anatomy education has resulted in incompetent clinical examinations (Jayasekera et al., 2005), unsafe clinical practices (Estai and Bunt, 2016), and consequently, an increase in medico-legal claims (Yammine, 2014).

Surface anatomy competency is a foundational component of medical education, providing students with essential skills for their future clinical practice and academic endeavours (Abu Bakar, Asma', et al., 2022). Proficiency in surface anatomy enables students to perform comprehensive physical examinations with precision and confidence (Farey et al., 2018). Palpating bony landmarks, identifying muscle attachments, and localising major blood vessels and nerves help students gain a thorough understanding of the anatomical structures that underpin human physiology and pathology (Abu Bakar, Hassan, et al., 2022). Surface anatomy competency not only improves anatomical knowledge, but it also develops the clinical skills required for accurate diagnosis and treatment planning (S. E. Smith & Darling, 2011). Its significance extends across a wide range of applications, including guiding clinical examinations, informing surgical interventions, interpreting radiological images, and promoting effective communication among healthcare professionals (Abu Bakar, Hassan, et al., 2022).

Surface anatomy proficiency begins with good observational skills and competent palpation techniques (Chinnah et al., 2011). Students learn to identify surface landmarks, variations, and anomalies using precise visual and kinaesthetic examination of anatomical structures (Kannamwar & Maske, 2019). This foundational competency allows healthcare professionals to conduct thorough physical examinations, accurately assess patients, and guide appropriate diagnostic and therapeutic interventions (Villaseñor-Ovies et al., 2019). By mastering observation and palpation, practitioners gain a profound understanding of surface anatomy, which is critical for navigating the complexities of the human body in clinical practice (Boon et al., 2002).

Surface mapping and clinical correlation are critical components of proficient surface anatomy skills (Dim EM et al., 2022). This includes the ability to locate surface landmarks onto underlying anatomical structures and link these findings to physiological function, pathology, and clinical presentations (C. F. Smith & Mathias, 2011). By bridging the gap between surface anatomy and clinical practise, students can enhance their diagnostic accuracy, treatment efficacy, and procedural planning skills, allowing them to make informed decisions in a variety of healthcare settings (Dim EM et al., 2022). Practitioners who understand the clinical relevance of surface anatomy can make informed decisions and provide optimal patient care across a wide range of healthcare specialties (Yammine, 2014).

Moreover, mastery of surface anatomy is indispensable in surgical practice, where surgeons rely on a thorough comprehension of surface landmarks to navigate complex anatomical structures safely and efficiently (S. E. Smith & Darling, 2011). Whether performing routine procedures or intricate surgeries, precise knowledge and skill of surface anatomy guide incisions, minimizes risks of iatrogenic injury, and optimises patient outcomes (Morgan et al., 2017).

Furthermore, proficiency in imaging interpretation is an essential learning competency expected from surface anatomy education. Integration of surface anatomy with radiological imaging facilitates the interpretation of diagnostic studies, enabling clinicians to correlate radiographic findings with anatomical structures and clinical presentations (So et al., 2017). Medical students are expected to be able to interpret radiographic images and other imaging modalities to identify internal anatomical structures relative to surface landmarks (Moscova et al., 2015). This competency is critical for diagnosing medical conditions, planning interventions, and monitoring treatment outcomes (Kapur et al., 2016). By integrating imaging findings with their surface anatomy knowledge, students indicate their readiness to provide comprehensive patient care by using diagnostic techniques in clinical practise (Royer, 2016b).

Effective communication is another key competency expected of medical students in surface anatomy education and training. Beyond its clinical applications, proficiency in surface anatomy enriches medical education by fostering effective communication among healthcare professionals (Esteghamati et al., 2016). Clear and concise anatomical terminology enables students to articulate diagnostic findings, discuss treatment options, and collaborate seamlessly with colleagues across interdisciplinary teams (Hale et al., 2010a). Moreover, translating complex anatomical concepts into lay terms enhances patient understanding and promotes shared decision-making, thereby improving health outcomes (Esteghamati et al., 2016).

Professionalism in surface anatomy emphasises the ethical conduct, compassionate care, and commitment to lifelong learning expected of medical students (Abu Bakar, Asma', et al., 2022). Students are expected to demonstrate ethical awareness and cultural sensitivity, emphasising the value of patient-centred care and diversity in healthcare settings (McDaniel et al., 2021). By acknowledging ethical concerns and addressing cultural sensitivities, practitioners foster a compassionate and inclusive approach to patient care, ultimately improving health outcomes and patient satisfaction (Kane et al., 2021). Respectful and empathetic treatment of patients during physical examinations reflects sensitivity to their vulnerability and prioritises their comfort and dignity (Abu Bakar, Hassan, et al., 2022).

In essence, competency in surface anatomy goes beyond technical proficiency, embodying the values and virtues that distinguish outstanding healthcare professionals (Abu Bakar, Asma', et al., 2022). These core concepts and competencies provide a framework for teaching and learning surface anatomy, guiding curriculum development, assessment strategies, and ongoing professional development (Johnson et al., 2012). They promote interdisciplinary integration, clinical relevance, and ethical awareness, fostering a holistic understanding of the human body and its clinical significance (Shin et al., 2022).

To overcome the substandard surface anatomy education, researchers have suggested the adoption of multimodal strategy in the pedagogy as an effective approach in teaching and learning (Johnson et al., 2012; Estai and Bunt, 2016). The multimodal strategy was effective as it allowed application of modern teaching modalities, namely, imaging technologies, computer assisted learning, problem-based learning, clinical correlation, peer teaching, team-based learning, and simulation, to complement the traditional method of anatomy teaching (Johnson et al., 2012; Losco et al., 2017). Different teaching methods can be used to supplement other teaching approaches to help learners attain their surface markings competency (Abu Bakar, Asma', et al., 2022). Nevertheless, the impact of these teaching modalities in surface anatomy remains unclear and neglected.

Surface anatomy is best learned through clinical scenarios. Surface anatomy is frequently taught alongside clinical cases, patient examinations, and radiological images (Abu Bakar, Asma', et al., 2022). This approach enables students to apply their knowledge in real-world scenarios. Experiential learning is critical for understanding surface anatomy (Abu Bakar, Asma', et al., 2022). Students can explore surface landmarks, palpate bony prominences, and identify muscle attachments through practical hands-on sessions with peers or models. Body painting, in which students mark anatomical landmarks on each other, offers an enjoyable and interactive learning experience (Woon & Hadie, 2022).

Despite its importance, surface anatomy is frequently given limited time in curricula due to other competing subjects (Stabile, 2015). Educators face difficulties in scheduling adequate time for practical sessions. Because of the limited time and resources allocated to surface anatomy in the modern medical curriculum, it is difficult to implement multimodal approaches and effective teaching strategies in surface anatomy education (Abu Bakar, Hassan, et al., 2022). The effectiveness of multimodal teaching strategies in authentic learning environments should be investigated through research. Having said that, the use of work-based learning could offer multimodal approaches within limited resources and time because patient and workplace could be used for teaching (Abu Bakar, Hassan, et al., 2022). Integrating surface anatomy more seamlessly into medical curricula may improve students' surface anatomy and clinical skills.

Malaysia's medical curriculum has shifted from traditional to hybrid systems. Currently, the majority of the local medical schools use the integrated curriculum (Ismail, 2017). In Malaysia, the medical curriculum structure is composed of preclinical or basic medical sciences and clinical phases, whereby surface anatomy is taught during first two years of the medical course (medic.usm.my; www.ukm.my; www.unisza.edu.my). Because of the limited time allocated for surface anatomy in the system-based medical curriculum, the subject is routinely taught as a lecture or a learning outcome in a gross anatomy lecture in the majority of government universities (medic.usm.my; www.ukm.my; www.unisza.edu.my). Furthermore, surface landmarks or related skills are taught in a practical session on a cadaver or on a living human in a clinical skills session (medic.usm.my; www.ukm.my; www.unisza.edu.my). Due to the difficulties in providing effective surface anatomy education, institutions should play an important role in supporting the improvement of surface anatomy instruction by providing trained facilitators, a conducive learning environment, and technology-enhanced teaching (Abu Bakar, Asma, et al., 2022).

Ever since the last century, surface anatomy has been positively acknowledged in medical education, institution and practice. However, the rapid transformation of medical education and substandard surface anatomy instruction prompted a scholar surface anatomy pedagogy that is systematic (Hale et al., 2010) and grounded by evidence and theories, (Asad and Nasir, 2015). In the modern integrated medical curriculum, a work-based approach could be a potential solution to provide an effective surface anatomy education as it could enhance the competency of surface anatomy knowledge and skills of preclinical year medical students. To outweigh the benefits of work-based learning for surface anatomy, a solid framework of this teaching strategy should be developed and validated before it is implemented. To ensure the effectiveness of the framework, researchers should attempt to embrace potential solutions that are supported by empirical evidence and principles of learning theories to fill the gap in surface anatomy education (Bergman et al., 2013).

1.4 Significance of the study

This study constructed a novel teaching model that is grounded by the principles of effective strategies in the WSAT model. The teaching model is important as it provides a pragmatic approach for educators to teach surface anatomy effectively based on the present evidences (Abu Bakar et al., 2022). The WSAT model serves as a practical guide with strategies and step-by-step method for anatomists to prepare and conduct a surface anatomy teaching in a work-based environment. Additionally, the WSAT model is equipped with a relevant explanation on the theoretical reasoning of its strategies to assist potential users in conceptualising the principles in work-based surface anatomy.

With the demand of vertical and horizontal integration in modern medical curriculum, the WSAT model can potentially become a useful pedagogy method in anatomy education and medical curriculum, since the clinical application is one of the chief components in this modality. the WSAT model can also serves as a medium to link the concept of anatomy with clinical knowledge. Furthermore, this model can be incorporated in early clinical experience slot of medical curriculum. As a result, anatomists can teach relevant professional behaviours and ethical values during the surface anatomy classes, which is normally difficult to apply in a classroom setting. The clinical application and professionalism learning in the WSAT-based teaching would also provide an opportunity for the development of higher order thinking. Since the WSAT model integrates basic sciences knowledge and clinical concepts, an interdisciplinary collaboration among different health professionals could be engaged in the medical curriculum, which consequently optimises the learning resources for effective learning.

Furthermore, the WSAT-based teaching can provide an opportunity for pre-clinical medical students to experience future working environment; henceforth allow them to understand and appreciate the responsibility of a medical practitioner at the early stage of the medical training. With the WSAT model, students would be allowed to apply the learned anatomy knowledge in a contextualised environment. Consequently, student would understand the importance of surface anatomy knowledge and motivate them to learn the subject and enhance their skills for future career. The intrinsic motivation is a pertinent factor in developing a competent, responsible and professional medical practitioner.

1.5 Research questions

The research questions in this study are presented according to the study phases. Since the Phase 1 of this study involves with the development of the WSAT model, there was no research question generated. There were two and nine research questions generated for Phase 2 (research question 1 and 2) and Phase 3 (research question 3 to 11) respectively. The research questions are listed as follows:

1. What is the content validity evidence of the WSAT model?
2. What is the response process validity evidence of the WSAT model?
3. What are the differences in the intrinsic and extraneous load scores between the intervention and control groups?
4. What is the difference of the self-perceived learning score between the intervention and control groups?
5. What are the differences of the cognitive, physical and emotional engagement scores between the intervention and control groups?
6. What are the differences of the baseline cognitive, psychomotor and professional behaviour competency scores between the intervention and control groups?
7. What are the changes in the cognitive, psychomotor and professional behaviour competency scores from pre-teaching to 10-week post-teaching, within the study groups?
8. How are the students' experience on learning surface anatomy through the allocated teaching method?

1.6 General objective

To design a valid WSAT model and investigate its impact on students' learning competencies in surface anatomy.

1.7 Specific objectives

The specific objectives in this study are presented according to the study phases.

1.7.1 Specific objective for Phase 1

1. To design and develop the WSAT model.

1.7.2 Specific objectives for Phase 2

2. To investigate the content validity of the WSAT model for surface anatomy teaching.

3. To investigate the response process validity of the WSAT model for surface anatomy teaching.

4. To investigate the internal structure of the WSAT model for surface anatomy teaching

1.7.3 Specific objectives for Phase 3

5. To investigate students' cognitive load on learning surface anatomy topics after exposure to the WSAT model by determining the:

a. difference of the intrinsic load score between the WSAT and control groups

b. difference of the extraneous load score between the WSAT and control groups

c. difference of self-perceived learning score between the WSAT and control groups

6. To determine the difference of students' cognitive, physical and emotional engagement scores during learning surface anatomy topics between the WSAT and control.

7. To investigate students' competencies on learning surface anatomy by determining the differences of:

a. the baseline cognitive, psychomotor and professional behaviour competency scores between the WSAT and control groups

b. the post-teaching cognitive, psychomotor and professional behaviour competency scores after teaching between the WSAT and control groups

c. the ten-week post-teaching cognitive, psychomotor and professional behaviour competency scores between the WSAT and control groups

d. improvement of cognitive, psychomotor and professional behaviour competency scores within study groups

8. To explore the students' learning experience through the allocated surface anatomy teaching method

1.8 Hypotheses

The hypotheses in this study were developed according to the study phases, which were confined to testing the quantitative variables of this study.

1.8.1 Phase 1

Since Phase 1 involves with the development of the WSAT model, there was no hypothesis generated.

1.8.2 Phase 2

1) Hypothesis 1 (for Objective 2): The content validity indices of the WSAT model are more than 0.8.

2) Hypothesis 2 (for Objective 3): The response process validity indices of the WSAT model are more than 0.8.

3) Hypothesis 3 (for Objective 4): The internal structure validity index of the WSAT model is more than 0.75.

1.8.3 Phase 3

3) Hypothesis 4 (for objective 5a): The intrinsic load score is lower in the WSAT than the control groups.

4) Hypothesis 5 (for objective 5b): The extraneous load score is lower in the WSAT than the control groups.

5) Hypothesis 6 (for objective 5c): The self-perceived learning score is higher in the WSAT than the control groups.

6) Hypothesis 7 (for objective 6): The cognitive, physical and emotional engagement scores is higher in the WSAT than the control groups.

7) Hypothesis 8 (for objective 7a): There is no difference in the baseline cognitive, psychomotor and professional behaviour competency scores (pre-teaching activity assessment score) between the WSAT and control groups.

8) Hypothesis 9 (for objective 7b): The post-teaching cognitive, psychomotor and professional behaviour competency scores are higher in the WSAT than the control groups after the teaching session.

9) Hypothesis 10 (for objective 7c): There are significant differences in the 10-week post-teaching cognitive, psychomotor and professional behaviour competency scores between the WSAT and control groups.

10) Hypothesis 11 (for objective 7d): There are significant changes in the cognitive, psychomotor and professional behaviour competency scores from pre- to post-teaching activity assessment scores within the intervention groups.

1.9 Operational definition

1. **Learning competency:** This term could be defined as the ability of learner to apply a set of related knowledge, skills, and behaviours that are required to successfully achieve the learning outcomes in a defined context. There are

three main learning competency domains for learning assessment, namely, cognitive, psychomotor and affective. The competency can be assessed at different levels based on the learning taxonomies for cognitive (Bloom, 1956), psychomotor (Simpson, 1972) and affective (Krathwohl et al., 1973). In this study, learning competency is viewed in the perspective cognitive, psychomotor and professional behaviour.

2. **Content validity:** Content validity is a type of validity that evaluates the relevancy and representativeness of items towards the intended measured construct in a measurement tool or an educational instrument (Cook and Beckman, 2006). The content validity of an instruments is commonly evaluated through expert judgement ratings and is considered as an essential source of validity evaluation (Polit et al., 2007; Yusoff, 2019). In this study, the content validity was evaluated by measuring the expert's judgment on the relevancy and representativeness of the WSAT strategies towards its domains.
3. **Response process validity:** It is a type of validity that measures the thought processes of potential users on the intended constructs in the examined tool or instrument (Cook and Beckman, 2006). Response process validity is important evidence if validation as it provides the overall validity of an assessment tool (Yusoff, 2019). In this research activity, the response process validity of the WSAT model was evaluated through the potential users' ratings on the clarity and comprehension of the strategies after a training session.
4. **Cognitive load:** This refers to the learner's mental workload on the working memory while learning. According to the cognitive load theory, a successful learning is depending on the capacity limits of the working memory load, whereby it can be influenced by intrinsic load and extraneous load (Kalyuga,

2011). In this study, the three constructs of cognitive load were evaluated (i.e. intrinsic load, extraneous load, and self-perceived learning, which represents the germane load).

5. **Intrinsic load:** This load refers to a type of cognitive load base that is required for learning. This load is imposed by the difficulty level of an instruction and is influenced by the learner’s prior knowledge (Sweller, 2010).
6. **Extraneous load:** This load refers to cognitive load that is not essential for learning. In other words, the extraneous load is unnecessary or wasteful load to the working memory during learning process, and thus hampers learning (Swelller, 2010).
7. **Self-perceived learning:** Self-perceived learning refers to an individual's subjective assessment or judgment of their own learning progress, knowledge acquisition, or skill development. It encompasses their beliefs, attitudes, and confidence levels regarding their own learning abilities and outcomes (Klepsch & Seufert, 2021).
8. **Engagement:** This term refers to the willingness of learners to invest their cognitive, emotion and psychomotor abilities in the learning process in order to understand the learning concept (Burch et al., 2014; Bernard, 2015). In this study, the three constructs of the learning engagement were explored (i.e. cognitive, emotion, and psychomotor engagement).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents the background literature on anatomy education, surface anatomy teaching, and work-based instruction in medical education. Because the primary goal of this research is to develop a valid and reliable work-based surface anatomy teaching model, the literature on the evidence of validity of instructional tool and educational model is presented, and the impact of anatomy teaching model on cognitive load, learning engagement and learning competencies is reviewed.

2.2 Anatomy teaching

Anatomy is an important foundation in medical education as it provides basic knowledge on human body structures and functions. Therefore, mastery of anatomy knowledge and its related skills are essential for safe clinical practice and procedures (Morris et al., 2016). Since the early twentieth century, anatomy instruction has undergone significant evolution in its curriculum structures and syllabus in response to changes in medical education (Woo & Tay, 2005). Due to the ambiguity and uncertainty of certain elements in medical education curricula in the early 20th century, a considerable number of unqualified students who were not fully equipped to practice medicine were enrolled in proprietary medical schools throughout the United States (Weissmann, 2008). To address these problems in medical training, Flexner's report in 1910 proposed a contemporary university-based medical education model that is equipped with curriculum consisting of meticulous instruction in basic sciences (Abraham Flexner, 1910). The landmark report also highlighted that medical faculty should be heavily involved in fundamental research, which subsequently resulted in the establishment of basic biomedical sciences department in the medical schools (Weissmann, 2008).

Following the Flexner landmark report, the approach of anatomy pedagogy has been influenced by the reformed of medical education, in which the medical curriculum has been segregated into two distinctive phases, namely, preclinical and clinical phases (Pawlina, 2009). Correspondingly, the anatomy syllabus was extremely long and majority of the contents in the anatomy were irrelevant to the clinical practice (Monkhouse, 1992). The transformation in medical education has also enhanced the prominence of the anatomy education in medical curriculum, whereby anatomy has been taught with in-depth scientific information (Woo & Tay, 2005). Nonetheless, the pedagogical approach of anatomy teaching in a compartmentalised discipline-based medical education had consequently resulted in two major drawbacks, namely, the inability of medical students to apply basic sciences concepts in clinical contexts, and poor basic medical sciences knowledge among the clinical-year medical students (Gwee et al., 2010).

Due to the deficiencies in the compartmentalised medical curricula, medical education system across the globe had undergone significant revamp from traditionally discipline-based curriculum to a more clinically integrated approach based on the General Medical Council recommendations (Heylings, 2002). The new curriculum approach combines the learning of basic and clinical knowledge, and emphasises the implementation of the system-based and problem-based learning in medical education (Leung et al., 2006).

The transformation of medical education into a clinically integrated approach has prompted another radical reform in anatomy education, resulting in a drastic reduction in the time and resources allocated to anatomy teaching (Dangerfield et al., 2000; Drake et al., 2009; Estai & Bunt, 2016; Monkhouse, 1992; Woo & Tay, 2005). This reform resulted in further adaptation in anatomy teaching, such as the application of problem-based modality, utilisation of prosected specimens and models over cadaveric dissection, application of radiographic images, utilisation of simulations, and the incorporation of ethics and professionalism in the anatomy pedagogy (Leung et al., 2006). Furthermore, advances in medical technology have prompted further modifications in anatomy instruction through the use of innovative teaching strategies, such as multimedia imaging (Zurada et al., 2011), online anatomy modality (Ozer et al., 2017), body painting (Cookson et al., 2017), virtual anatomy software (Asad & Nasir, 2015), and clinically-integrated instruction (Barry et al., 2019; Ikah et al., 2015). With the availability of various teaching methods and strategies , as well as the demands of modern medical education, educators have been conducting research to find effective pedagogical approaches in anatomy, and attempting to implement these evidence-based strategies in anatomy instruction (Backhouse et al., 2017; Bergman et al., 2012).

Previous reviews have recommended multimodal teaching as an effective teaching strategy in anatomy (Abu Bakar, Asma', et al., 2022; Asad & Nasir, 2015). Multimodality in teaching can be described as an instruction that apply multiple modes of representation to provide different types of resources to the learners in a meaningful learning experience (Papageorgiou & Lameras, 2017). With the use of various teaching modalities, limitations of a teaching method could be overcome. For example, a didactic lecture with a lack of interactive learning environment, can be supplemented with other of teaching modality, such as virtual synchronous instruction that promotes interactive learning among students (Estai & Bunt, 2016). By adopting multimodality principle in various modern teaching tools such as radiological images, computer-assisted learning, clinical correlation lectures, peer teaching, team-based learning, and simulation strategies, teaching can be enhanced with clinical integration and learning can be improved with flexible education (Johnson et al., 2012; Losco et al., 2017). Nonetheless, despite recent studies highlighting the multimodal approach as an effective strategy in anatomy teaching, the impact of these methods in surface anatomy education in general remains inconclusive and should be investigated.

2.2.1 Surface anatomy teaching

Surface anatomy can be conceptualised as the anatomy knowledge that deals with the external features of the human body, whereby the knowledge can be learned without performing a cadaveric dissection (Hale et al., 2010b). The surface anatomy concept encompasses two subdivisions, namely, (1) palpable anatomy, which refers to the knowledge related to anatomical structures that lie immediately beneath the skin and detectable through palpation; and (2) projectional surface anatomy, referring to the knowledge of anatomy that is related to the surface projection of unpalpable body structures that lie deep in the human body such as the heart (Hale et al., 2010a).

Surface anatomy is considered as one of the fundamental learning components in anatomy education (Sugand et al., 2010). In medical education, the understanding of surface anatomy concept is essential for the students to appreciate the basic sciences concept underlying the clinical practice (Boon et al., 2002). To be a competent clinical practitioners, medical students must be able to recognise the anatomical structures underlying the human skin for them to perform precise clinical examination, interventional procedures, and interpret radiological images (Aggarwal et al., 2006). Therefore, surface anatomy competencies is crucial for the development of clinical and procedural skills for the future clinical practice, which needs to be acquired by the medical students prior to graduation (Azer, 2013). Several studies reported that substandard surface anatomy competencies among medical graduates has resulted in incompetent clinical practitioners and increase in medico-legal claims (Yammine, 2014) due to the inaccurate clinical examinations (Jayasekera et al., 2005) and unsafe clinical practices (Estai & Bunt, 2016).

Surface anatomy education varies across different regions globally, reflecting diverse educational philosophies, healthcare systems, and cultural contexts. In the United States, surface anatomy education often follows a clinical-based approach, where students learn anatomical concepts alongside clinical practice (Shin et al., 2022). This approach emphasises the immediate application of anatomical knowledge in a clinical setting, providing students with hands-on experience and exposure to real-life patient care scenarios (Shin et al., 2022). While this approach offers valuable clinical relevance, students may encounter challenges in comprehensively understanding anatomical systems, particularly those not directly relevant to their clinical rotations (Sbayeh et al., 2016).

On the other hand, in the United Kingdom, surface anatomy education is often integrated within a broader medical curriculum. Students receive comprehensive anatomical training that is intertwined with other basic and clinical sciences, promoting a holistic understanding of human anatomy and its relevance to medical practice (C. F. Smith et al., 2022). This integrated approach allows students to appreciate the interconnectedness of anatomical structures with other disciplines and fosters a deeper understanding of the underlying principles of anatomy (Morgan et al., 2017). Similar to the UK, Australian medical education often emphasizes integration across disciplines, providing students with a comprehensive understanding of anatomy within the context of clinical practice (Trautman et al., 2019).