Faculty of Cognitive Sciences and Human Development

THE EFFECT OF GENDER AND LEARNING MEDIUM ON KNOWLEDGE ACQUISITION

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THE EFFECT OF GENDER AND LEARNING MEDIUM ON KNOWLEDGE ACQUISITION

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ABSTRACT

This study aims to investigate the differences between gender and learning medium in knowledge acquisition. The entire research was conducted in University Malaysia of Sarawak (UNIMAS) whereby 60 participants were recruited by means of random sampling. The basis of this research was limited to a quantitative study by merely screening and populating the test sample with participants who were from different faculties and no prior academic or general knowledge on brain structure. Three different types of learning medium were prepared; printed text, 2D cross-modal learning medium and 3D cross-modal learning medium to present the participants with a visual-tactile cross modality learning experience. The participants were subject to two different phases. The first was the study phase. The participants were required to study the learning content based on the learning medium they received. This was followed with the test phase where the participants were tested using a test that consists of 20 questions. A Two-way Independent ANOVA test was used to test the research questions. This study found that there was a significant different in knowledge acquisition between gender however there was no significance difference in knowledge acquisition across the three different types of learning mediums. This study also found that there was a significant difference in terms of interaction between gender and learning medium in knowledge acquisition.

Keywords: Knowledge Acquisition, Gender, Learning Medium, Cross Modality, Dual Coding theory

ABSTRAK

Kajian ini bertujuan untuk mengkaji perbezaan antara jantina dan media pembelajaran dalam pemerolehan pengetahuan. Seluruh kajian telah dijalankan di Universiti Malaysia Sarawak (UNIMAS) di mana 60 peserta telah direkrut melalui persampelan rawak. Asas penyelidikan ini terhad kepada kajian kuantitatif dengan hanya menyaring dan mengisi sampel ujian daripada peserta yang berasal dari fakulti yang berbeza dan tidak mempunyai pengetahuan akademik atau umum yang terdahulu mengenai struktur otak. Selain itu, tiga jenis pembelajaran disediakan iaitu teks bercetak, media pembelajaran *2D cross-modal* dan media pembelajaran *3D cross-modal* untuk membentangkan peserta dengan pengalaman pembelajaran modaliti silang visual dan gerakan. Peserta tertakluk kepada dua fasa yang berbeza. Yang pertama ialah fasa pembelajaran. Para peserta dikehendaki belajar kandungan pembelajaran berdasarkan medium pembelajaran yang mereka menerima. Ini diikuti dengan fasa ujian di mana peserta diuji dengan 20 ujian soalan. Statistik inferensial digunakan untuk menguji soalan penyelidikan dengan menggunakan ujian Analisis Dua Hala (ANOVA Bebas Dua Hala). Kajian ini mendapati bahawa terdapat perbezaan yang ketara dalam pemerolehan pengetahuan antara jantina namun tidak terdapat perbezaan yang signifikan dalam perolehan pengetahuan antara tiga jenis media pembelajaran. Kajian ini juga mendapati terdapat perbezaan yang signifikan dari segi interaksi antara jantina dan media pembelajaran dalam pemerolehan pengetahuan.

Kata kunci: Pemerolehan Pengetahuan, Jantina, Media Pembelajaran, Modality Salib, Teori Pengkodan Dual

CHAPTER ONE

INTRODUCTION

Knowledge acquisition is the process of absorbing and storing new information in memory where the retrieval of the information depends heavily on the representation and organization of the information (StateUniversity, 2018). Knowledge acquisition occurs through three processes which are impression, association and repetition (Orin, 2014). Firstly, impression occurs when one is impressed by multimedia elements such as audio, text, model or movement during the learning process. This increases the chances of remembering through the strength of impression. Secondly, the association process occurs when one uses or links their prior knowledge or pre-existing knowledge to the newly learned knowledge. Thirdly, the process of repetition on the newly acquired knowledge to ensure a good memorization and effective retrieval of the information or knowledge.

There are many ways to learn and obtain new knowledge by further applying it to daily practices. One can acquire knowledge through the traditional method of learning in school or through self-directed learning with the usage of educational multimedia that provides an incredible amount of information within a few clicks of the keyboard. This is because technology has improved drastically over the past decades. The increase in the rate of accessibility of technology for teachers or educators to use technology-based teaching has led to an increment in the usage of supportive tools such as video modelling, web platform and animated content in education and learning (Eady &Lockyer, 2013).

A wide variety of technological advancement has played an important role in how knowledge is successfully acquired through the understanding, implementing and creating of better knowledge material. Flexible technological advancement has led to the creation of Computer-based training (CBT) which is a self-paced learning activity that is displayed on a computer or electronic device such as a tablet or smartphone (Edwin, 2017). CBT can be

widely and readily used to customize the learning material for knowledge acquisition. The process of knowledge acquisition were correlated with the application tools such as E-learning in order to provide an effective learning experience (Kiselev, Yakutenko & Yuriev, 2017). Electronic learning or E-learning is a learning process that is enhanced by the use of computers and it provides an efficient way of studying, comprehending and understanding of new knowledge (BrainCert, 2015). However, the rate of knowledge acquisition depends on the optimization of one's actions to receive the best results by further utilizing the best way of learning for proper knowledge acquisition (Kiselev, Yakutenko & Yuriev, 2017).

The rate of knowledge acquisition can be tested by observing the student's verbal responses such as orally or written towards any questions on topic of interest such as Science, Mathematics and Geography (Tecks, 2018). The answers will be classified as correct if the student's answer matched the meaning of the real answers. New knowledge acquisition rate of the student is assumed to be directly proportional to the quantity of correct answers achieved by the student. Apart from that, knowledge acquisition also can be further tested by propositions such as facts, concept names, definitions, statements and principles (Tecks, 2018). The process of understanding the content of a proposition is demonstrated by the ability of the student to respond accurately to the questions about that particular proposition by remembering the meaning of the original proposition (Tecks, 2018).

Traditionally, education had been characterized by the acquisition of knowledge in various subject areas such as Mathematics, History and Science with the objective of covering a block of information separated by themes and topics (Elina, 2018). Generally, science is the study of the structure, function, growth, origin, evolution and distribution of living organisms where the representation of the contents play a crucial role in knowledge acquisition of the student (UnderstandingScience, 2019). Students' understanding had traditionally been measured by final grades on assessments which required memorization and

regurgitation of facts that applied to all subject areas (Elina, 2018). As a result, majority of the diagram, terminology and explanation in the science syllabus need to be understood and memorized therefore a proper delivering and learning medium needs to be applied for an effective knowledge acquisition. In addition, the Ministry of Education suggests that effective teaching and learning strategies on the stimulation and enhancement of the students' thinking ability in science curriculums need to be emphasized (Elangovan & Ismail, 2014).

Furthermore, McHugh mentioned that traditional teaching environment is unattainable with the learning style of current generation where most of the students are inclined and motivated towards technology and gadgetry such as mobile phones, tablets and laptops in their daily life (Tan & Waugh, 2013). Hence, the implementation of multimedia technology as a learning medium in education needs to present itself. This will eventually be effective and offer deeper knowledge to students in their learning process. The effectiveness of a learning medium should not only be based on the characteristics such as text, image and audio but the instructing and studying method that are implemented in the learning medium as well (Reiser, 1994). For instances, ICT based teaching such as computer stimulations showed positive impacts in teaching and learning science subjects (Wellington as cited in Elangovan & Ismail, 2014). This was due to the features of real movement, graphical displays, colour and instructional design that provided a real simulation of learning and teaching environment into the classroom (Elangovan & Ismail, 2014).

Although there have been many studies comparing 2D and 3D learning mediums, it is worth to note that most of the comparison studies performed had prepositioned distinctive motives such as to only test the spatial ability using 3D and 2D objects and the geometric thinking using 2D and 3D geometry (e.g. Cockburn, 2004; Dickey, 2005; Ismail & Rahman, 2017). Therefore, this validates the argument that there is a lack of comparison specifically made between 2D and 3D (Richard & Talyor, 2015). The main difference between 2-

Dimensional and 3-Dimensional is their appearances and depth. The 2D consists of X axis and Y axis that produced flat surfaces while the 3D is made of X axis, Y axis and Z axis where the Z axis produced the depth effect that contributed to volume (ADMEC Multimedia, 2014). Moreover, the 2D applied frames with no realistic feature in them whereas the 3D comprised of modelling, rendering and animation which carries a realistic and simulation appeal. Accordingly, the different type of learning medium used in the computer such as 2D and 3D provide different types of modalities such as vision, hearing and tactile which lead to simultaneous integration of information (Lee & Lee, 2018). Research conducted by Tan and Waugh (2013) showed that the use of virtual reality (VR) which composed of 3D virtual objects were able to increase the interest and engagement of students, further building their attention and focus during the learning process. During the interview session, the students that engaged in VR learning explained that the visualization of the biology molecule provided better attention and understandings of the molecule concept. Hence, Tan and Waugh (2013) concluded that visualization on conceptualized 3D object was useful in understanding the biology concept which further increased the achievement in knowledge acquisition.

Elangovan and Ismail (2012) conducted a quasi-experimental simulation study for six weeks on Form Four Biology classes to determine the effectiveness of two different forms of three dimensional (3D) computer simulation in learning biology molecule. Non-realistic simulation referred to the desktop virtual reality simulation while the realistic simulation was taken from 3D multimedia simulation. Their research showed that both the non-realistic and realistic simulation produced a positive effect in learning biology however the 3D simulation was able to increase the student's understanding and achievements better than the non-realistic simulation. This was noted due to the simple fact that the non-realistic simulation lacked depth effect. The 3D structure learning medium also provided a better understanding

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to the students in solving the task with different complexities such as mathematical geometry and matrix (Ferk as cited in Korakakis, Pavlatou, Palyvos & Spyrellis, 2009).

In contrast, research conducted by Ismail and Rahman (2017) to investigate the student's learning and geometric thinking in 3D and 2D geometry with Geogebra showed that the students performed better in geometric thinking by using 2D geometry due to the complexity of 3D geometry for visualization. Furthermore, one of the research conducted by Richard and Talyor (2015) showed that the learning rate of the students were faster when they were learning biological theorem with 2D learning medium as compared to 3D learning medium. In their study, the students showed improvement in learning by using 2D learning medium as the 3D learning medium end resulted in cognitive load due to the high dimension interfaces that required navigation such as rotation and translation. This finding was contradicted with the above experimental research (e.g. Elangovan & Ismail, 2014; Tan & Waugh, 2013) which showed a positive result of the 3D learning medium in learning biology subject. These showed mixed findings were found across the study of 2D and 3D learning medium. Therefore, this study was conducted to address the mixed controversies between 2D and 3D learning medium.

Cross-modality is the ability to integrate information from different sensory modalities such as visual, tactile and auditory (Lee & Lee, 2018). It acts as a cognitive interaction on multimedia-based learning with stimulus-reinforcement which makes it convenient to arrange the information through the use of a multisensory element such as vision, hearing or tactile (Chan & Black, 2006). The learning medium refers to the used of sensory channels including vision, tactile and auditory in learning. In fact, greater part of the learning medium empowered the students to learn and comprehend from visualization (Elangovan & Ismail, 2014). According to Dwyer, the usage of different sensory modalities in learning medium increases the presentation of educational content (Lee & Lee, 2018).

Furthermore, the rapid advancement in technology has easily enabled the conversion of unimodal learning medium to cross-modal learning medium. This can be defined as a combined modality which is the simultaneous integration of senses by enabling the learners to stimulate their cognitive domains in the learning environment (Lee &Lee, 2018). A study conducted by Lee and Lee (2018) showed that learning medium that applied cross-modality of vision and tactile facilitated the knowledge acquisition in learning heart structure through smartpads. However, to select an optimal modality from this vast array of alternatives were difficult as each modality has its own set of information representation characteristics that makes it excellent for the representation of certain information types and awful for others (Uden & Campion, 2001). The combination of two or more of these modalities might exacerbate the problem or task as several modalities are involved.

Apart from that, the effects of gender on cognitive abilities have been largely investigated in the past across various context as well (e.g. Berk, 2009; Harplen, 2004). Research conducted by Cowards, Crooks, Flores and Dao (2012) showed a significant difference between genders in the comprehension test. They suggested that males and females greatly differ in their mental abilities. In their study, they showed that females were more effective in processing verbal information compared to males. This is because females required less mental effort in processing verbal information (Harplen, 2004). Eventually females are able to free up more memory spaces to process spatial information. Besides, females were more rapid to access phonological, semantic and episodic information in long term memory which leads them to obtain high scores in tests regarding verbal learning and comprehension (Harplen, 2004). This parallels with Paivio's dual-coding theory which mentioned that concepts that are coded in both visual and verbally written were more likely to be remembered. Dual-coding theory is a theory of cognition based on human's process by

representing verbal and non-verbal information in separate and related systems (Chegg, 2018).

Studies conducted by Korakakis, Pavlatou, Palyvos and Spyrellis (2009) showed that the spatial ability among genders were different and it produced an impact on comprehension of 3D computer visualization. Computer visualization involves rotation, representation and inversion of 3D objects compared to when they were displayed in 2D form (Korakakis, Pavlatou, Palyvos & Spyrellis, 2009). Furthermore, students who used spatial imagery and diagrams ought to perform better than students who used verbal strategies when engaged in complex problem-solving tasks in science and mathematics subjects (Spelke, 2005). The reasoning behind this observation was noted as the growth in spatial working memory is positively correlated with mathematics proficiency (Li & Geary, 2013). Quaiser-Pohl and Lehamann (2002) concluded that spatial ability in females were much more dominant compared to experiential and attitudinal-which are predominant in males. In their study, attitudinal referred to an individual's overall perception of favourableness or un-favourableness towards the learning material which comprised of affective and cognitive dimensions. Meanwhile, experiential referred to the individual's emotional response to the material presented to them. Their study showed that females' spatial ability was perceived based on their emotion and intuition. Furthermore, the study conducted by Bosco, Longoni and Vecchi (2004) showed that the selection and endorsement of varied cognitive strategies between genders did indeed influence the interpretation of an individual in determining a visual-spatial task (VSWM). It is in this aspect where males scored better than females in interpreting rotation and movement. The spatial representation was able to be conveyed into multiple spatial information from multiple modalities involving various brain regions in the processing of modality-specific information (Struiksma & Postma, 2017). However, based on the study conducted by Likouri, Klonari and Flouris (2017), they mentioned that male and

female eye pupils showed a similar total spatial perception. The males and females of their sample could discern, perceive, and mentally rotate the 3-dimensional shapes from different visual angle. Consequently, it showed mixed results were found among genders' knowledge acquisition from multimedia learning.

The effectiveness of a presentation with certain multimedia designs were processed and understood differently by individuals of different genders. For instances, males facilitated by dual-mode presentations fared best while females performed best from single mode presentation (Riding & Grimley, 1999). In addition to gender, other individual differences such as cognitive style, prior knowledge and different multimedia designs also impacted on student learning. Altogether, preceding researches had displayed some full-size evidence or clarification in theoretical aspect such as differences in brain density, the way of approaching the task and spatial ability of why males and females differ. However they do emphasized on the importance of considering gender factor in learning medium research to improve the design and development of education multimedia. If males are better at processing dual presentation and females are better at processing single mode, does the cross-modality of the learning medium affect their knowledge acquisition? Do males tend to outperform females when presented with multiple modality designs of learning medium? Therefore it is hoped that this study will be able to address the gender gap in knowledge acquisition using the different types of learning mediums.

On another note, Baddeley stated that working memory can be classified into two sub-systems which are processing visual information and verbal information (Cowards, Crooks, Flores & Dao, 2012). Each system has a limited capacity of cognitive processing where either verbal or visual arise at any time. Therefore, the presentation of learning medium through visually with audio or tactile illustration lead to the need of different modality to work simultaneously. A study was conducted to examine the effect of gender and presentation

mode on learning from multimedia presentations by Cowards, Crooks, Flores and Dao (2012). In their study, the presentation mode referred to the text narration with animation or static image in the multimedia learning. Their study showed a significant difference in the comprehension test between the genders and the presentation mode presented on the multimedia learning. Females were able to achieve higher scores compared to male participants in the comprehension test. They found that the task that required more than one sensory perceptual lead to cognitive load. Furthermore, an experimental research was conducted to determine the use of specific types of visualization such as 3D illustration, 3D animation and interactive 3D animation in learning a science course (Korakakis, Pavlatou, Palyvos & Spyrellis, 2009). They found that the 3D interactive learning medium lead to cognitive load. Based on Mayer's cognitive theory on learning medium, the complexity of instruction strained the memory resources during the selection in sensory memory and the organization in the visual channel (Cowards, Crooks, Flores & Dao, 2012). This related to the spilt attention principle in multimedia learning. It was found that the increased flexibility provided by the 3D presentation makes the interaction harder to understand which further lead to worst task performances (Ayres & Sweller, 2005). Thus, the cognitive interactivity on multimedia should evolve to handle sufficient information for knowledge acquisition that will be processed successively in working memory by further considering the limited capacity and period of working memory with the partially separated channel of auditory, vision and tactile channels that are unable to hold many schemas (Korakakis, Pavlatou, Palyvos & Spyrellis, 2009).

Hence, this study intended to measure the knowledge acquisition of the students by using different types of learning medium which are printed text, 2D cross-modal learning medium and 3D cross-modal learning medium. As mentioned above, the mixed finding across the researches with 2D and 3D learning medium provided inconsistent result to the

knowledge acquisition. Thus, this study would be able to address the gap between 2D and 3D learning mediums. This study also explored whether the brain structure is easier to understand via the traditional method or can be more readily understood by 2D and 3D cross-modal learning medium. Apart from that, this study compares the effectiveness of the learning medium in terms of cognitive interaction through knowledge acquisition based on the score of test.

The primary focus of this study was to investigate the effect of gender and learning medium on knowledge acquisition. Hence, this study mainly involved three different types of learning mediums which are printed text, 2D cross-modal learning medium and 3D cross-modal learning medium. In addition to the main effect of interaction, factors such as gender was tested along with the three learning mediums. The dependent variable of this experimental research was knowledge acquisition while the independent variables were the gender and learning medium. Specifically, the present study addressed the following research questions:

(1) Is there any significant difference in knowledge acquisition across the three different types of learning mediums (printed text, 2D cross-modal and 3D cross-modal)?

(2) Is there any significant difference in knowledge acquisition between genders?

Overall, this study was designed on prior researches by comparing three different learning medium and suggests the implications for design theory in terms of cognitive interaction. Furthermore, most of the past studies focused on how to improve the interaction design in multimedia learning. Only a handful of studies have been conducted based on the learner's cognitive interaction in the learning medium. Moreover, this study positively contributed to weakening controversies of 2D and 3D learning mediums. This study was

further replicated to involve factors such as gender, as the effectiveness of multimedia learning in facilitating knowledge acquisition may be different between genders.

CHAPTER TWO

METHOD

This study investigated the effects of gender and learning medium on knowledge acquisition. In particular, the present study focused on the learning of brain structure among UNIMAS undergraduate students with three different types of learning mediums. A 2 × 3 factorial design was used by crossing two type of gender which are male and female with three different types of learning mediums which are printed text, 2D cross-modal learning medium and 3D cross-modal learning medium.

Participants

The population of this study comprised of undergraduate students of University Malaysia Sarawak (UNIMAS). 60 participants comprising 30 males and 30 females from different faculties in UNIMAS were recruited for this study using random sampling except from the Faculty of Medicine and Health Sciences and Faculty of Cognitive Science and Human Development as they had already acquired the prior knowledge on brain structure due to their learning syllabus in medical and cognitive neuroscience.

Research Design

Three learning mediums were prepared for the participants. These were printed text, 2D cross-modal learning medium and 3D cross-modal learning medium. In the printed text learning medium, participants used the modality of visual and tactile such as highlighting, underlining and note taking in learning. The 2D cross-modal learning medium and 3D cross-modal learning medium applied the modality of visual and tactile as well in learning. Between subject design was applied in this study where two groups of gender with 30 males and 30 females were recruited and further separated. Then, multi-group design approach was conducted where they were presented with different types of learning medium. Printed text

learning medium acts as the controlled group meanwhile 2D and 3D cross-modal learning medium act as the experimental group. The effectiveness of knowledge acquisition was collected through the answered test.

Table 1

Cognitive Interaction for Respective Learning Medium

Learning Medium	Cognitive Interaction
Printed Text	Highlight, Underline, Sketching
2D Cross-modal	Tactile, Visual
3D Cross-modal	Tactile, Visual

Research Instrument

The experiment instrumentation needed for this study was specifically selected to ideally suit the challenges of this study over two phases; study phase and test phase. The learning medium that was used during the study phase is printed text on paper followed by 2D and 3D brain structure which was presented via desktop followed by a mouse that was prepared for interaction purpose. The two experimental condition were presented with the different types of brain dimension (2D and 3D) along with verbally written information regarding the brain function. The printed text and 2D cross-modal learning medium were extracted from Brainwave Center website meanwhile the 3D cross-modal learning medium was extracted from BioDigital website. Brainwave Center is an education technology website that is designed to improve students' success using open educational resources (OER) while BioDigital is empowering a new era of creativity by making it easy for anyone to publish and find 3D content online. On the other hand, the test used to test the knowledge acquisition during the test phase was extracted from major brain quiz websites such as Science Hub. The