DEVELOPMENT AND PERCEIVED USABILITY OF 3D-MODEL PLASMAMESH AS A TEACHING AID FOR SUBTOPICS IN PLASMA MEMBRANE

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UNIVERSITI PENDIDIKAN SULTAN IDRIS

2024

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THIS FINAL YEAR PROJECT SUBMITTED IN FULFILLMENT OF THE REQURIEMENT FOR THE BACHELOR'S DEGREE OF EDUCATION (BIOLOGY) WITH HONORS

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ABSTRACT

The study aims to create a 3D model "PlasmaMesh" as a teaching aid for plasma membrane-related subtopics in Form Four (4) Biology. The research objectives are to develop a 3D model PlasmaMesh as a teaching aid with high validity and to determine the perceived usability of the product developed. This research is Developmental Research Design (DRD) guided by the ADDIE model guided throughout the product development process. The research utilized two instruments: a validity evaluation form for experts to validate and a perceived usability questionnaire for respondents to provide feedback. The validity of the product was analyzed by Content Validity Index (CVI). The I-CVI for the product analyzed was 1.00 for each item summing up for a total of 16 items, value interpreted was located in the range of 1.00 for three experts' validation. A pilot study was conducted to access the reliability of the research instruments, measuring methods through Cronbach's Alpha, yielding a value of 0.871, indicating good reliability. For the field study, a total of 103 practical teachers from AT11 Biology Education from Universiti Pendidikan Sultan Idris (UPSI), spanning from semester six to seven were used as respondents. They assessed four constructs – content, design, usability and satisfaction using a 4-point Likert scale to evaluate the "PlasmaMesh 3D-model". Data collected was analyzed by descriptive quantitative analysis using Statistical Package for Social Sciences (SPSS), focusing on the measure of central tendency namely mean and standard deviation, revealed average values of 3.75 and 0.44 for content and design, and 3.75 and 0.43 for usability and satisfaction. The results indicated a high frequency of agreement (scale 3 – 4) with low dispersion of perception among respondents. In summary, the developed "PlasmaMesh 3D-model" has proven valid and usable as a teaching aid, benefiting teachers in enhancing the delivery of plasma membrane-related content be encouraging effective visualization of membrane components and substance movement. Implications of this research are to promote the use of physical models along with innovative teaching methods to facilitate active engagement between students to achieve the goals of 21st century teaching and learning (PAK-21).

ABSTRAK

Kajian ini bertujuan untuk mencipta model 3D bernama "PlasmaMesh" sebagai alat bantu mengajar untuk subtopik berkaitan membran plasma dalam Biologi Tingkatan Empat (4). Objektif kajian adalah untuk membangunkan model 3D PlasmaMesh sebagai alat bantu mengajar dengan kesahan yang tinggi dan untuk menentukan persepsi kebolehgunaan produk yang dibangunkan. Penyelidikan ini adalah Reka Bentuk Penyelidikan Pembangunan (DRD) berpandukan model ADDIE yang dipandu sepanjang proses pembangunan produk. Penyelidikan menggunakan dua instrumen: borang penilaian kesahan untuk disahkan oleh pakar dan soal selidik persepsi kebolehgunaan untuk responden memberikan maklum balas. Kesahan produk telah dianalisis oleh Indeks Kesahan Kandungan (CVI). I-CVI untuk produk yang dianalisis ialah 1.00 untuk setiap item yang dijumlahkan untuk sejumlah 16 item, nilai yang ditafsirkan terletak dalam julat 1.00 untuk pengesahan tiga orang pakar. Kajian rintis telah dijalankan untuk mengakses kebolehpercayaan instrumen kajian, kaedah mengukur melalui Alpha Cronbach, menghasilkan nilai 0.871, menunjukkan kebolehpercayaan yang baik. Untuk kajian sebenar, sejumlah 103 guru praktikal dari AT11 Pendidikan Biologi dari Universiti Pendidikan Sultan Idris (UPSI), bermula dari semester enam hingga tujuh mengambil peranan sebagai responden. Mereka menilai empat konstruk – kandungan, reka bentuk, kebolehgunaan dan kepuasan menggunakan skala Likert 4 mata untuk menilai "PlasmaMesh model 3D". Data yang dikumpul dianalisis secara deskriptif kuantitatif analisis menggunakan Statistical Package for Social Sciences (SPSS), memberi fokus kepada ukuran kecenderungan memusat iaitu min dan sisihan piawai, mendedahkan nilai purata 3.75 dan 0.44 untuk kandungan dan reka bentuk, dan 3.75 dan 0.43 untuk kebolehgunaan dan kepuasan. Keputusan menunjukkan kekerapan persetujuan yang tinggi (skala 3 – 4) dengan serakan persepsi yang rendah dalam kalangan responden. Secara ringkasnya, "model PlasmaMesh 3D" yang dibangunkan telah terbukti sah dan boleh digunakan sebagai alat bantu mengajar, memberi manfaat kepada guru dalam meningkatkan penyampaian kandungan berkaitan membran plasma serta menggalakkan visualisasi komponen membran dan pergerakan bahan yang berkesan. Implikasi kajian ini adalah untuk menggalakkan penggunaan model fizikal berserta kaedah pengajaran yang inovatif bagi memudahkan penglibatan aktif antara pelajar bagi mencapai matlamat pengajaran dan pembelajaran abad ke-21 (PAK-21).

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LIST OF ABBREVIATIONS

MOE	Ministry of Education
TLS	Teaching and Learning Session
HOTS	High Order Thinking Skills
DSKP	Dokumen Standard Kandungan Pembelajaran
RO	Research Objective
RQ	Research Question
DRD	Design Research and Development
BBM	Bahan Bantu Mengajar
SPSS	Statistical Package for Social Sciences
CVI	Content Validity Index
UPSI	Universiti Pendidikan Sultan Idris

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CHAPTER 1

INTRODUCTION

1.1 Preface

Science subjects namely Biology, Chemistry, Physics are fun to learn because science is not only limited only to its context as a teaching medium about facts, theories, principles and laws of nature (Han, Lai & Amatan, 2022). Biology is one of the dimensions that has continuous growth (Abdul Rahman, 2016), while only receiving small number if student enrollment due to students find it difficult to learn Biology (Prokop *et al*., 2007). However, to teach and spread the knowledge to students is a whole different story as it requires an educator or a teacher to be creative in lesson planning, effective in executing the lesson and to reinforce what have been taught in order to ensure development of students' ability to generate scientific knowledge systematically.

Malaysia, like many other nations, is experiencing significant growth and globalization, particularly in the field of education (Raman *et al*., 2015). Recognizing the importance of establishing a world-class education system, Malaysia has undertaken a comprehensive study led by the Malaysian Ministry of Education (MOE). The study aims to identify the essential factors that must be addressed and prioritized in order to achieve this objective. As a result, the country has implemented the 21st-century learning initiative, known as PAK21, which has been in effect since 2014 and continues to be implemented to this day. 21st Century Learning, or known in Malay as *Pembelajaran Abad ke-21* (PAK21), is a student-centered learning process characterized by five elements which are communication, collaboration, critical thinking, creativity and ethics (Julaihi & Hamdan, 2020). This initiative is also being emphasized by the Ministry of Education Malaysia (MOE) to encourage teachers to practice and implement creative strategies of PAK21 into their classrooms.

Therefore, to practice PAK21 during teaching and learning session (TLS), teachers require a suitable teaching aid or also known as *Bahan Bantu Mengajar (BBM)* in Malay to ensure the content knowledge can be delivered effectively from the teacher to their respective students. Through impactful teaching and learning sessions (TLS) using appropriate teaching aids, students can develop essential soft skills such as critical thinking, creativity, innovation, collaboration and communication, aiming to improve students' competency and marketability in society (Larson & Miller, 2011). Using only notes and textbooks only as “props” for education is no longer favorable, teachers must find alternatives through the use of modern teaching technique or tools to help foster students' communication and collaboration skills, integrating technology, promoting problem-solving abilities, innovative and creative thinking. In the 21st century, the

world has become increasingly challenging and demanding. There is a growing need for individuals (specifically younger generations) who are intellectually adapt, innovative and productive to induce development in various industries (Julaihi & Hamdan, 2020).

In this chapter, researcher will introduce the overview of the study based on the problems encountered, purpose of research in the background of the study. Also, including the operational definition of the terms (key words) utilized in this study. Research objectives will be aligned with the research questions to correlate together proving the study is significant to be used for references for teachers, researchers and etc to improve quality of education mainly focusing on development of models as teaching aid. Research significance and limitation are also addressed in this chapter. Finally, summarization of the whole research outline encouraging reader to have an idea on the research to be conducted (mode and design of research) before moving deeper into literature review and methodology.

1.2 Research Background

Malaysia has evolved from a production-based to knowledge-based economy in order to stay competent with other developed countries (Grapragasem, Krishnan & Mansor, 2014). A nation's success depends fundamentally on the knowledge, skills and competencies of students (Hoe, Chuan & Husin, 2019). The government, through the Ministry of Education (MOE), is responsible for delivering quality education to the people of Malaysia crucially the younger generations who is the key for future

development. The MOE's vision is to make Malaysia a center of educational excellence. Hence, the education system in Malaysia has gone through tremendous changes and transformation to nurture a generation equipped which fundamental skills of communication, collaboration, think creatively, innovatively and critically.

The Biology curriculum syllabus developed by the Malaysia Ministry of Education includes numerous topics encompassing various terms, processes, and biological concepts that students are expected to comprehend and master. However, despite the comprehensive curriculum, some students still struggle to achieve proficiency in the field of biology (Wan Mohamed Salleh *et al*., 2021). Hence, there must be something will lead to the present situation of students' losing interest and experiencing low performance in science specifically Biology. Whether is the unsuitable teaching strategies, insufficient effective teaching aid/ educational toolkit or other factors contributing to the phenomena above.

In the current biology teaching process, teachers still adopt the traditional teaching method with the use of static teaching materials plus oral instruction. Students cannot be stimulated to think in the classroom, unable to build up confidence and motivation in the subject of biology (Wang *et al*., 2023). It is difficult to imagine teaching, learning or doing biology without the use of visual representations (Quillin & Thomas, 2017), textbooks can no longer be considered as an important element of knowledge acquisition (Grapragasem, Krishnan & Mansor, 2014). In almost every instance of Biology education, problems encountered include misconceptions (Coley & Tanner 2012) and inability to connect knowledge of related topics at different hierarchy levels (Šorgo and Šiling 2017).

Furthermore, school-based assessments will likewise adapt the format towards emphasizing on higher-order thinking skills (HOTS) testing in order to shape and prepare students for the increasingly challenging future. But, can the students match up to the expectations of being able to answer HOTS questions without being taught properly using effective learning strategies accompanied by a good teaching aid. Visual aids like ICT, diagrams and 3D-models play a significant role in education by promoting student engagement, enhancing comprehension, generating interest and facilitating long-term retention of learned materials (Shabiralyani *et al*., 2015). Undoubtedly, an effective delivery tools is required as an ongoing effort to nurture individuals' potential in a holistic and integrated way, in order to produce persons who are academically, spiritually, emotionally and physically healthy and harmonious (Malaysian Educational Blueprint, 2013-2025).

Why is it essential for this research to focus on developmental of an effective teaching aid for subtopics of plasma membrane? Based on previous evaluation of plasma membrane learning activities conducted by Johann *et al.* (2022), the students had difficulties in understanding that cell membrane structure, components present and involved in maintaining living processes. Also, based on the model "Build-A-Membrane" proposed by University of Utah (2021), the model is able to present each component in the plasma membrane but lack the elements as an interactive model. Hence, I assume that there is a need to develop an interactive 3D-model named as PlasmaMesh to improve the quality of content knowledge delivery from teacher to students, with the aim to enhance students' understanding on this topic. For instance, the use of 3D-model benefit students as they can physically manipulate and interact

with the objects, rather than just listening to lecture and using static textbooks or notes only (Tian & Huber, 2020).

1.3 Problem Statement

The concept of cell biology including the concept of plasma membrane is abstract and difficult to understand causing many students find it to master the contents, resulting the low learning outcomes of the concept (Duda & Hilarius Jago, 2020). It occurs because Biology is a theoretical based subject which contains a lot of theories, concepts, diagrams, drawings and illustration accompanied by elaboration through writing. The main cause was lacking of learning strategies which involve the use of physical modelling to help students to visualize representations of the membrane bilayer (Dalali & Mwali, 2022).

Tan Sri. Dr Khair Mohammad Yusof, Director General of Education Malaysia (2013-2017) stated that PAK-21 does not only refer to the use of gadgets or technology in the classroom, but PAK21 also means applying teaching strategies with effective teaching aids to create more dynamic, interactive and personalized learning environments that enhance learning experience, engage students, promote critical thinking and facilitate collaboration. Therefore, 21st century teaching and learning is becoming a global trend including Malaysia as the learning environment includes a variety of teaching and learning skills accompanied by impactful educational aids that are tailored to the needs of the students, instead of just producing students that will pass or score in an exam (Julaihi & Hamdan, 2020).

Most of the Biology teachers often stick to conventional teaching style to impart knowledge from the curricular textbook to their student. Undoubtedly, in the past, conventional teaching and learning method is effective, prioritizing only on content knowledge rather than connecting students between knowledge and experience (Jaschik, 2018). Yet, the world is changing and improving towards the era of modernization, same goes for the field of education. The lack of adequate teaching aids significantly impedes students' ability to understand and grasp complex concepts in different subjects (Abdullah & Melor Md Yunus, 2019). Therefore, effective teaching and learning require an effective delivery system, textbooks can no longer be considered as an important element of knowledge acquisition (Grapragasem, Krishnan & Mansor, 2014).

Additionally, the absence of a practical teaching aid for cooperative teaching and learning hinders the potential for experiential learning among students. Experiential learning is highly related in the context of 21st century education as it involves engaging learners in hands-on experiences and promoting reflective thinking. By actively involving students (with teacher's guidance) in the utilization or operation of a teaching aid such as PlasmaMesh during teaching and learning sessions (TLS), students have the opportunity to acquire knowledge and develop practical skills through firsthand experiences (Andresen, Bold & Cohen, 2020).

Based on cumulative research by Raiyn (2016), "various studies report that 75 of all information processed by the brain is derived from visual formats. Furthermore, visual information is mapped better in students' minds" (p.115). Learners may find it difficult to visualize 2D images printed on textbooks and notes compared to 3D formats

to understand certain dynamic aspects of functional anatomy including components in Plasma Membrane (Azer & Azer, 2016). In simple words, visualization induce sensory learning (mainly visual) to assist students' learning by converting 2D diagrams into a touchable and usable 3D model such as PlasmaMesh where students can involve in the process of exploring and interact with the model. In short, learners understand information better in the classroom when they see it (Raiyn, 2016). Through this research, research will develop a teaching aid in the form of a 3D-Model named as PlasmaMesh to target and solve the problems related to misconceptions, alternative towards conventional teaching tools, enhance experiential and visual learning in teaching and learning session (TSL).

1.3.1 Need Analysis

Need analysis in research refers to the systematic process of identifying and assessing the requirements, gaps or necessities within a particular context or problem area (Creswell & Creswell, 2017). To reinforce the necessity of developing a physical model as a teaching aid for plasma membrane-related subtopics, the researcher conducted a need analysis during the practical session *"Latihan Mengajar 1"* with secondary school teachers currently in service. This involved using a simple questionnaire to collect data and opinions from ten (10) teachers—five (5) Biology and five (5) Science teachers at SMJK Chung Ling, Pulau Pinang. This enabled the researcher to identify any issues or challenges from the perspective of teachers who taught the topic, thus providing valuable insights for the decision to create an effective teaching aid as a solution. Figure 1 tabulated the respondents demographics particularly the teachers' level of experience in teaching based on years.

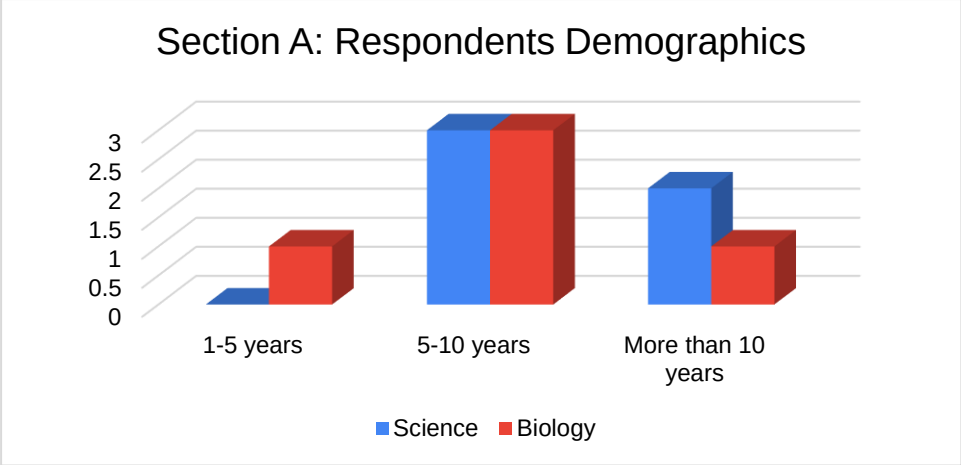

Figure 1. Section A of Need Analysis

Referring to figure 2, which highlights the current challenges and practices faced by teachers from SMJK Chung Ling in teaching subtopics related to the plasma membrane, the researcher concludes that a significant number of teachers encounter difficulties in delivering content effectively. There is a notable absence of an ideal teaching aid to help students visualize the membrane and substance movement. Teachers collectively express interest in implementing innovative teaching aids into their lessons.

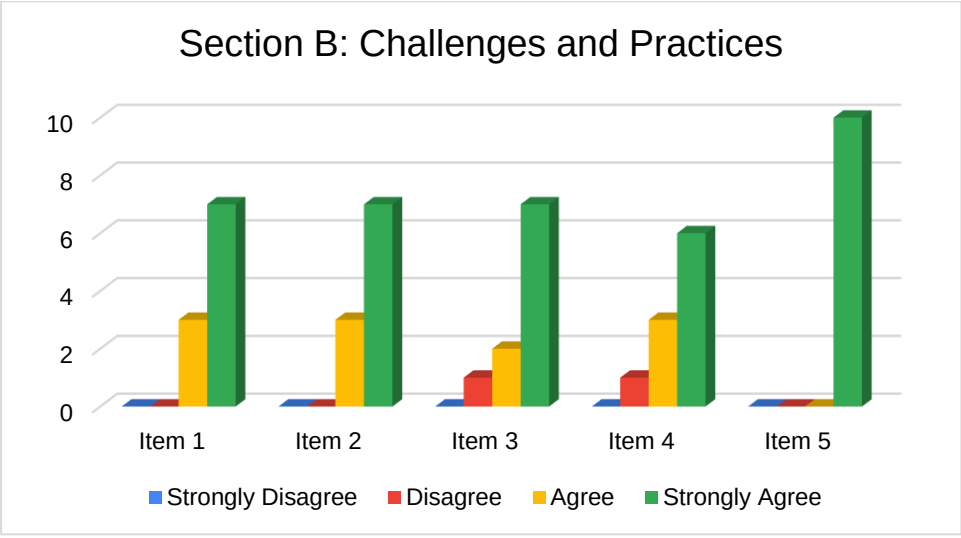

Figure 2. Section B of Need Analysis

Referring to figure 3, it highlights teachers' opinions on the ideal teaching aid and preferences, guiding the researcher in developing a valid product. As per the data, teachers prioritize aligning the product with *Dokumen Standard Kandungan Pembelajaran (DSKP)* content standards. They prefer a 3D format of the plasma membrane as a visually effective representation with movable features to illustrate substances movement. A clear user manual is crucial for usability, given teachers' time constraints. Portability and storage effectiveness are also key considerations.

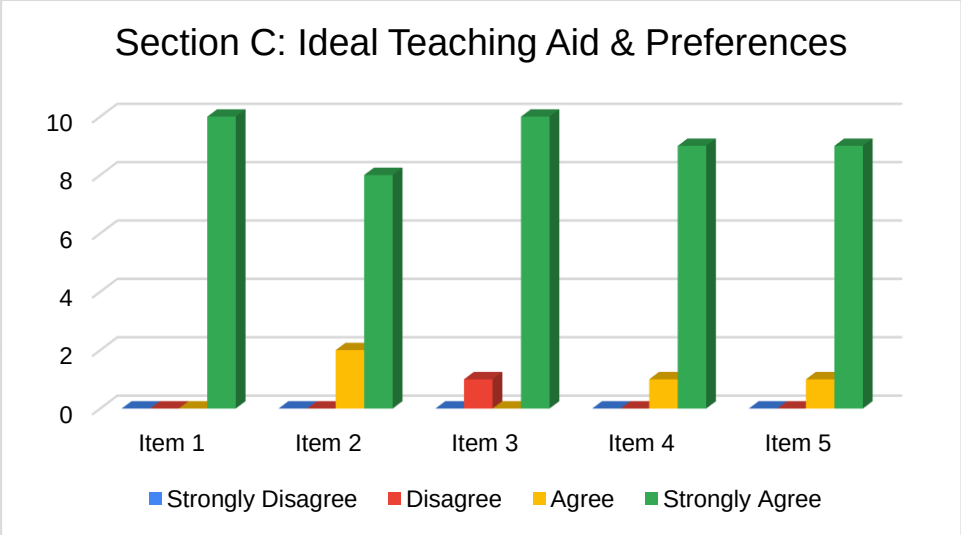

Figure 3. Section C of Need Analysis

Table 1

Items of Need Analysis (Section B)

Item	Description
1	I often encounter challenges in explaining subtopics related to the plasma membrane.
2	I think that subtopics related to the plasma membrane are abstract and challenging for students to comprehend.

3	The absence of effective teaching aids restricts teachers from implementing effective lessons to cover the subtopics of the plasma membrane.
4	I am not confident in delivering the contents for the subtopics related to plasma membrane.
5	I believe that innovative teaching aids can help students visualize the plasma membrane and comprehend the movement of substances.

Table 2

Items of Need Analysis (Section C)

Item	Description
1	The priority of the teaching aid must be to align with the content standards outlined in the *Dokumen Standard Kandungan Pembelajaran (DSKP)*.
2	A visual representation (in 3D-format) of plasma membrane will ease teachers to explain the components present within it.
3	Movable features shall be incorporated within the teaching aid to facilitate demonstration of substances movement by teachers.
4	The developed teaching aid must be accompanied by a clear and easy-to-understand user manual.
5	The teaching aid must consider portability, storage and user friendliness.

1.3.2 Summarization of Need Analysis

The data obtained from Section B (refer figure 2) illustrates a trend of agreement among secondary school Biology and Science teachers selected for the analysis, affirming that they face challenges in teaching subtopics related to the plasma membrane.

For item 1, 70% of respondents strongly agree while 30% agree showing that currently servicing teachers do encounter challenges to explain the subtopics of plasma membrane. This support the statement mentioning that concept of plasma membrane is abstract and difficult to understand by Duda & Hilarius Jago (2020). For item 2, same results where 70% of respondents strongly agree while 30% agree that there is a lack of teaching aid to implemented effective and engaging lessons for topics related to plasma membrane. This signifies the absence of practical teaching aid for 21st century education that is required to develop science processing skills through hands-on learning experiences (Association of Experiential Education, 2012).

Furthermore, item 3 received 60% of strong agreement and 10% of agreement that conventional textbooks and reference books are the primary choice of teaching aid. This reflects back to the problem statement of teachers often selectively use only conventional teaching style and tools to impart knowledge (Jaschik, 2018). Hence, item 5 concludes the needs analysis, indicating that servicing teachers desire to integrate innovative teaching aids for better visualization of the plasma membrane and substance movement. This motivates the researcher to utilize the PlasmaMesh 3D-model to resolve the difficulties of learners to visualize 2D images while learning (Azer & Azer, 2016).

1.4 Research Objective

a) To develop a 3D-Model PlasmaMesh as a Teaching Aid for Movement of Substances Across a Plasma Membrane that has high validity.
b) To determine perceived usability of 3D-Model PlasmaMesh as a Teaching Aid for Movement of Substances Across a Plasma Membrane.

1.5 Research Question

a) Does the 3D-Model PlasmaMesh developed as a Teaching Aid for Movement of Substances Across a Plasma Membrane has high validity?
b) Does the 3D-Model PlasmaMesh developed as a Teaching Aid for Movement of Substances Across a Plasma Membrane has high perceived usability?

1.6 Conceptual Framework of Research

The research will be focusing on developmental approach to find out whether 3D-Model PlasmaMesh is a proper teaching for the subtopics of plasma membrane (Chapter 3 – Form Four) based on validity and usability. Based on figure 4, few concepts and theories are used as reference to construct a product that can be used in the field of education. Firstly, Piaget's theory of cognitive constructivism (1970) used as fundamental to support the content relevance on the 3D-model. Piaget's proposes that humans cannot be given information, in which they immediately understand and use. Instead, learners must construct their own knowledge through experience.

Next, Kolb's theory (1984) suggests that learning is a cognitive process that requires continuous adaptation and active engagement with one's environment. According to Kolb's experiential learning cycle, individuals generate knowledge through personal experiences rather than solely relying on passive instruction. Therefore, the PlasmaMesh 3D model will likely to be an interactive model rather than static model based on both theories suggested.

Then, 3D reconstructing method (Irschick *et al.*, 2021) are taken into consideration for designing and building the product. This method refers to techniques and algorithms used to create three-dimensional (3D) representations of objects, scenes or environments from 2D images, building something into an actual object. Basically, this 3D reconstructing method aims to recover the 3D structure and geometry of the object of interest (example: organs and structures) mainly for anatomical study in Biology.

Lastly, ADDIE instructional design model (1975) is the core used for product design of PlasmaMesh. This model is given more focus because it is structured programmed with sequences of systematic activities (5 steps approach) in efforts to solve learning problems related to learning resources (teaching aid / educational toolkit) that are in accordance with the needs and characteristics of students (Widyastuti & Susiana, 2019).

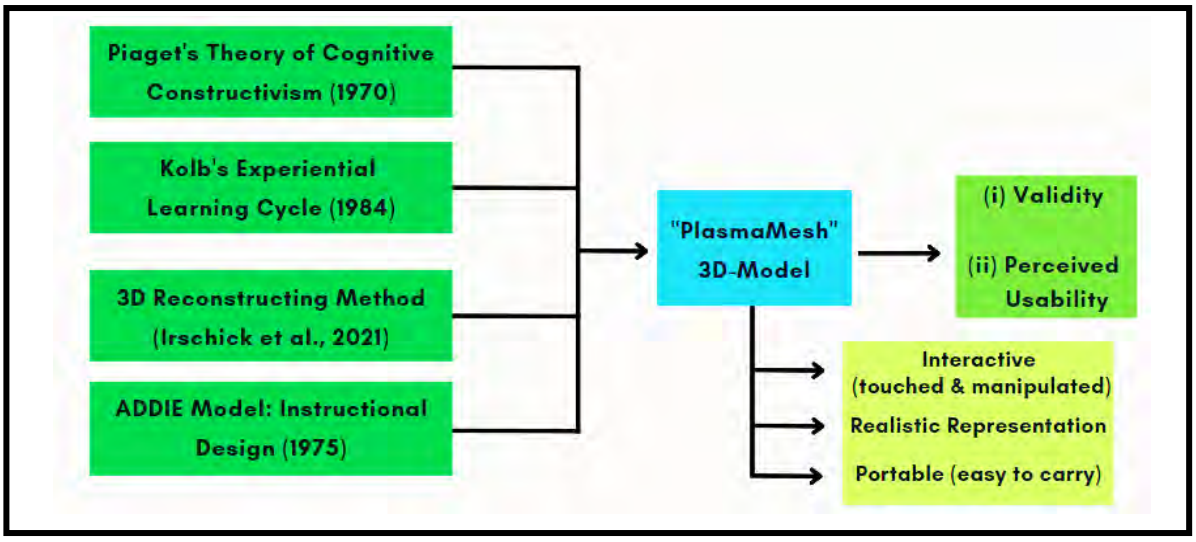

Figure 4. Conceptual Framework for PlasmaMesh 3D-Model Development

1.7 Operational Definition

An operational definition is a precise and comprehensive elucidation of how a variable is evaluated or managed in a research inquiry (Cameron & Bernstein, 2022). The present study has identified several terms that are important to define in the context of the research.

1.7.1 Development

According to the Cambridge Dictionary (2024), the term "development" signifies the "process of growing or changing and becoming more advanced" or can denote the "process that creates something new". In the field of education, the continual development of new activities, teaching and learning methods, as well as teaching aids or tools, stands as one of the most important parts of education at all levels which ensures a continual improvement (Indarta *et al*., 2021). This research will emphasize on Design Research and Development (DRD) by employing the ADDIE model. This

approach involves designing, developing and evaluating the product of PlasmaMesh 3D-model to assess its effectiveness in resolving the identified problems that are at the core of this developmental research (Zaharudin *et al*., 2021).

1.7.2 Perceived Usability

The concept of usability stems from the notion of being user-friendly (Gupta, Ahlawat & Sagar, 2014). Usability is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (Kuijk *et al*., 2015).

Perceived usability is how users personally judge the ease of use, efficiency, effectiveness and satisfaction of a product based on their own experiences and opinions (Orfanou *et al*., 2015). In this study, researcher will gather perceptions from pre-service teachers on the usability of the 3D-model PlasmaMesh as a teaching aid to assist teacher in teaching and learning session (TSL).

1.7.3 3D-model

A physical 3D model refers to a tangible portrayal of an object or environment, replicating its three-dimensional form, physical attributes and spatial connections. It enables users to engage in physical interaction and visually examine a scaled or realistic representation of the subject matter (Kwon *et al*., 2020). In this research, a product named as PlasmaMesh will be created as a physical 3D model to be used as a teaching aid for the subtopics related to Plasma Membrane. Why 3D model instead of a simpler

2D version? Common teaching aid or *Bahan Bantu Mengajar (BBM)* utilized by teachers are textbooks and notes (physical) or PowerPoint slides (virtual) only provide two-dimensional (2D) and static anatomical illustrations, learners may find it difficult to visualize 2D images compared to 3D format of representations to understand certain dynamic aspects of functional anatomy (Azer & Azer, 2016).

Physical 3D model can provide a hands-on representation that can be touched, examined and manipulated to enhance understanding and communication (Xie *et al*., 2018). Hence, by rotating and manipulating the model from different angles, only the students can identify and understand the organization of components in the plasma membrane.

1.7.4 Teaching aid

According to The Random House Dictionary (2017) “Teaching Aid is the material used by a teacher to supplement classroom instruction or to stimulate the interest of students”. A teaching aid is an educational tool (book, notes, chalk board), an item (such as a model or specimen), or a gadget (such as a DVD or computer) that a teacher uses to supplement or enhance classroom training. Teaching aids (TAs) are instructional tools and equipment that assist teachers in carrying out the teaching and learning process (Kapur, 2018). Teaching aids (TAs) are tools used by teachers to help students understand lesson concepts. Their purpose is to make lessons engaging and easier to grasp. By using TAs, teachers aim to simplify the learning process and ensure students can efficiently understand and absorb the contents (Alshatri *et al*., 2019).

1.7.5 Validity

Essentially, validity is concerned with the accuracy (Borsboom, Mellenbergh & Van Heerdan, 2004) or trustworthiness (Joint Committee for Standards on Educational Evaluation, 1994) of the scores produced. Validity pertains to the degree to which a test or measurement precisely captures the intended target of measurement. It guarantees that the outcomes derived from a test or evaluation are significant and indicative of the underlying idea or concept being assessed (Joint Committee on Standards for Educational and Psychological Testing, 2014). Validity will be used to evaluate the product PlasmaMesh to identify the content relation towards the subtopics of plasma membrane and the fulfillment of criteria(s) to be called as an interactive model.

1.8 Study Limitations

i. Mode of research

In this study, the mode of research will be focusing on development of a product to be used as a teaching aid. The product PlasmaMesh is a 3D-model which is made to target the subtopics of plasma membrane. However, due to research limitations, we cannot directly test its effectiveness on form four (4) Biology students. Instead, we are collecting data from experts like school teachers or professionals in the field of cell biology for validation purposes. Furthermore, to determine the usability, perceptions from AT11 Biology pre-service teachers of Universiti Pendidikan Sultan Idris (UPSI) are gathered to assess whether PlasmaMesh is a product suitable to be used as a teaching

aid. To sum up, the effectiveness and impact of PlasmaMesh cannot be identified due mode of developmental research having restrictions from testing on actual students.

ii. Time-consuming process

Development of a product especially physical ones (non-virtual) requires much preparation and planning to ensure the product is relevant towards the topics & subtopics while content knowledge can be delivered successfully. The core theory that supports the whole development of PlamaMesh is ADDIE model which involves five (5) steps, (i) analysis (A) to get information of the needs of developing such product, (ii) design (D) to sketch and draft out the looks of the product using hand or software, (iii) development (D) to build and construct each components involved in the PlasmaMesh model using air clay and other materials (iv) implementation (I) to pilot test the 3D model on selected pre-service teachers to collect data and feedbacks for improvements and finally (v) evaluation (E) to conduct actual study through validity assess by experts and usability by pre-service teachers (larger sample than pilot study). The whole procedure using ADDIE model can be time-consuming in order to achieve a desirable outcome of high content validity (CVi) and high perceived usability.

iii. Limited topics

This product PlasmaMesh can only be utilized for specific subtopics in plasma membrane (chapter 3) because the chapters include concepts like osmosis which cannot be represented by the PlasmaMesh model. The main aim is to illustrate the phospholipid bilayer and the location of different components (cholesterol, glyco-lipid and protein) to enhance visualized teaching and learning. In addition, the design and interactive parts of the model can only describe the concept of passive transport using pore protein and

carrier protein, active transport can also be presented using moveable carrier protein design.

To be specific, the PlasmaMesh is suitable for the subtopic of 3.1: Structure and 3.2: Concept of Substances Movement, while lacking the ability to be used for subtopic 3.3 and 3.4 which relates the movement of substances in living cells (animal and plant cells).

1.9 Importance of Research

As the field of education in Malaysia continues to experience development, the Ministry of Education Malaysia has made the use of teaching aid or known in Malay as *bahan bantu mengajar (BBM)* an important component in teaching and learning session (TLS) in every school (MoE, 2012). The application of various forms of teaching aids can make teaching and learning sessions (TLS) more engaging and effective, thereby enhancing students' understanding and learning (Jamalludin & Zaidatun, 2003).

The use of teaching aid schools requires the readiness of teachers in terms of their skills and attitudes so that the teaching aid can achieve maximized performance effectively during teaching and learning session (TLS). However, there are still some teachers who are less interested in using teaching aid due to the design and usability of the teaching aid not applicable for certain topics or subjects (Umair Ahmed *et al*, 2018). Teachers may find it hard to implemented for actual teaching because lack of consideration on teachers' skills to operate the new innovative teaching aid (Umair

Ahmed *et al*, 2018) and to suite to a class of students with different learning styles including visual, auditory, kinesthetic and etc (Coffield *et al*., 2004).

Therefore, in this developmental research, researcher targets to create a 3D model named as PlasmaMesh to target on the subtopics related to plasma membrane. By incorporating different elements into the PlasmaMesh model such as interactive, spatial understanding, portability (easy to carry) to function as a visual representation of the fluid mosaic model of plasma membrane. Teaching aid help teachers to improve quality of content delivery (by teacher) and learning (by students), also to induce students' engagement, sparking their interest to explore and study (Noor Azlan & Nurdalina, 2010). Using PlasmaMesh as classroom activity induce students to actively involve in operating the 3D-model enhancing experiential learning for processes like active & passive transport.