DEVELOPMENT AND EVALUATION OF MAMAXGENIUS MATERNAL EFFECT BOARDGAME FOR UNDERGRADUATE BIOLOGY STUDENTS

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FACULTY OF SCIENCE AND MATHEMATICS

DECLARATION OF ORIGINAL WORK

This declaration is made on the ..... (day) ..... (month) 2024

i. Student's Declaration

I, **NUR AIN FAIQAH BINTI ZAMRI (D20201095378)** hereby declare that the Final Year Research Project Report entitled **DEVELOPMENT AND EVALUATION OF MAMAXGENIUS MATERNAL EFFECT BOARDGAME FOR UNDERGRADUATE BIOLOGY STUDENTS** is my original work. I have not plagiarized from any other scholar's work and any sources that contains copyright had been cited properly for the permitted meanings. Any quotations, excerpt, reference or re-publication from or any works that has copyright had been clearly and well cited.

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ii. Supervisor's Declaration

SYAZWAN BIN SAIDIN hereby certify that the work entitled **DEVELOPMENT AND EVALUATION OF MAMAXGENIUS MATERNAL EFFECT BOARDGAME FOR UNDERGRADUATE BIOLOGY STUDENTS** was prepared by the above-named student, and was submitted to the DEPARTMENT OF BIOLOGY for the conferment of BACHELOR OF EDUCATION (BIOLOGY) WITH HONORS, and the aforementioned work, to the best of my knowledge, is the said student's work.

Date Signature of the Supervisor

Acknowledgement

The completion of this thesis would not have been possible without the invaluable support and encouragement of numerous individuals. It is with deepest gratitude that I acknowledge them here.

First and foremost, I express my immense appreciation to my parents. Their unwavering faith in me, even during moments of doubt, provided the bedrock of strength and motivation I needed to persevere. Their sacrifices and wise advice have been the guiding light throughout my academic journey. Thank you Abah and Ibu, truly, this daughter of yours has been blessed by your presence and support.

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To all those who have offered their help and support in countless ways, my sincere thanks. I am truly grateful for your presence in my life. Thank you.

ABSTRACT

Biology students at universities must learn about a variety of topics related to genetics. Non-mendelian genetics, particularly the maternal effect, is one of the topics covered in genetics. Maternal effect explained the influence of the mother's genetics onto the offspring's phenotype. The purpose of this study is to develop MamaXGenius card games as learning aids and to investigate the perception of biology majors students on the use of MamaXGenius for the topic Maternal Effect in Genetic. The ADDIE model had been utilised in the development stage. This study involved 170 biology students that took the Genetic subject for Semester 3 to 7. The instruments used in this study are questionnaires to evaluate the validity of MamaXGenius, assess the validity of a perception questionnaire, and gauge perceptions through a four-point Likert scale. For the validity of the MamaXGenius card game, two experts of secondary school teachers with high expertise and extensive experience in pedagogical practices were chosen. The CVI value obtained for the questionnaire and the card game 'MamaXGenius' was 0.989, while Cronbach's alpha coefficient is 0.854. Both values can be interpreted as accepted and good respectively.The acquired data undergoes analysis by using descriptive statistical methodology to ascertain mean values, frequency percentages, and standard deviations. The calculated averages for each construct were 3.73 (SD=0.480) for content, 3.74 (SD=0.468) for construct usability and playability, as well as 3.78 (SD=0.439) for construct satisfaction. The results suggest that the respondents in this research perceive the use of MamaXGenius card game positively. This study thus demonstrates that the MamaXGenius card game is appropriate for use as a teaching tool to improve students' comprehension of the Maternal Effect in the Genetics classroom. This shows that teachers and lecturers may utilise game based learning by implementing MamaXGenius in teaching maternal effect topics, while students may use this card game to gain better understanding of the concept in this topic.

Keywords: Game-Based Learning, Gameboard, Teaching Aid, Genetic, Maternal Effect

PEMBANGUNAN DAN PENILAIAN PERMAINAN PAPAN KESAN MATERNAL MAMAXGENIUS UNTUK PELAJAR BIOLOGI PRA-SISWAZAH

ABSTRAK

Pelajar biologi di universiti perlu mempelajari tentang pelbagai topik yang berkaitan dengan genetik. Genetik bukan mendelian, terutamanya kesan maternal, adalah salah satu topik yang diliputi dalam genetik. Kesan maternal menjelaskan pengaruh genetik ibu kepada fenotip keturunan. Kajian ini bertujuan untuk membangunkan permainan kad MamaXGenius sebagai bantuan pengajaran dan mengkaji persepsi pelajar jurusan biologi tentang penggunaan MamaXGenius untuk topik kesan maternal dalam genetik. Model ADDIE telah digunakan dalam fasa pembangunan. Kajian ini melibatkan 170 pelajar biologi yang mengambil subjek Genetik untuk Semester 3 hingga 7. Instrumen yang digunakan dalam kajian ini adalah soal selidik untuk menilai kebolehpercayaan MamaXGenius, menilai kebolehpercayaan soal selidik persepsi, dan mengukur persepsi melalui skala Likert empat titik. Untuk kebolehpercayaan permainan kad MamaXGenius, dua pakar guru sekolah menengah dengan kepakaran tinggi dan pengalaman yang luas dalam amalan pedagogi telah dipilih. Nilai CVI yang diperoleh untuk soal selidik dan permainan kad 'MamaXGenius' adalah 0.989, manakala pekali alfa Cronbach ialah 0.854. Kedua-dua nilai boleh ditafsirkan sebagai diterima dan cemerlang masing-masing. Data yang diperoleh melalui kajian ini dianalisis dengan menggunakan metodologi statistik deskriptif untuk menentukan nilai min, peratusan kekerapan, dan sisihan piawai. Purata yang dikira untuk setiap konstruk adalah 3.73 (SD=0.480) untuk kandungan, 3.74 (SD=0.468) untuk konstruk kegunaan dan bermain, serta 3.78 (SD=0.439) untuk konstruk kepuasan. Keputusan menunjukkan bahawa responden dalam kajian ini mempersepsikan penggunaan permainan kad MamaXGenius secara positif. Oleh itu, kajian ini menunjukkan bahawa permainan kad MamaXGenius sesuai untuk digunakan sebagai alat bantu pembelajaran dalam meningkatkan pemahaman pelajar untuk kesan maternal dalam kelas Genetik. Hal ini menunjukkan bahawa guru dan pensyarah boleh menggunakan pembelajaran berasaskan permainan dengan melaksanakan MamaXGenius dalam mengajarkan topik kesan maternal, manakala pelajar boleh menggunakan kad permainan ini untuk mendapatkan pemahaman yang lebih baik mengenai konsep dalam topik ini.

***Kata kunci**: Pembelajaran Berasaskan Permainan, Papan Permainan, Alat Bantu Mengajar, Kesan Maternal, Genetik*

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LIST OF ABBREVIATIONS

ADDIE	Analysis, Design, Develop, Implement and Evaluate
AT11	Biology students major
CVI	Content Validity Index
I-CVI	Item Content Validity Index
MEB	Malaysia Education Blueprint
S-CVI	Scale-level Content Validity Index
SPSS	Statistical Package for Social Science
STEM	Science, Technology, Engineering and Mathematics
UA	Universal Agreement
UPSI	Sultan Idris Education University

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CHAPTER ONE

INTRODUCTION

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1.1 Introduction

This chapter discussed the background and problem statement of this research, as well as research objectives, research questions, conceptual framework, operational definition, significance and also acknowledged the limitations associated with this research.

1.2 Research Background

Students are a crucial aspect of a nation as they are the future of what a citizen could offer to its country, thus there is a rising need to further equip these students, also often coined as learners, to be able to have the necessary skill set and knowledge. DePaul (2023), stated that in return of helping students enhance their learning, they will succeed in both their studies and also in their

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life. Therefore, this highlights the importance of helping the students to learn properly as supported by Ordu (2021), that explained the students would need to be active learners and have the room to reflect on their learning in order for them to reach global competence for their future.

One of the ways to help these students in enhancing their learning, is that the teachers could prepare appropriate teaching aid. Ordu (2021), stated that teaching aid, or learning aid consists of any devices, instructional aids or objects that may help teachers in delivering teaching-learning processes in a more seamless action. The selected teaching aids will then enrich the classroom experience, increase the attention span of the students and also provide motivation for them to learn. For example, the usage of teaching aid in the classroom not only eases the teaching burden of a teacher, but also has an exceptionally good effect on the students. Istiqomah *et al*. (2022), further explained that students are able to acquire knowledge, foster their psychomotor skills and develop their creativity in solving problems due to the usage of teaching aids.

According to Maycock (2017), chalk and talk technique involves the usage of utilising a white board with the material from the module generated for the students in addition to the students taking down their own notes. Through the study conducted by Maycock (2017), it can be seen that students that were taught by chalk and talk technique appear to have lower results as compared to the usage of flipped learning.

Game-based learning styles had been used more and more in current teaching by teachers alike. The rise to the need for game-based learning implementation is due to the present-day students that are well versed in the knowledge of technologies and surrounded by the ever-growing technology era. According to Liu, Zaffar Ahmed, and Gazizova (2020), in today's world we live in, it can be observed that at least the second generation of individuals referred to as 'native digital' are maturing. These individuals have grown up in a digital world and consider it to be their natural environment since birth. On the other hand, according to Siti Shahida, Abdul Halim, Mahizer, and Munirah (2021), in order to foster students with abilities relevant to the 21st century, the classroom teaching style must be suitable with the growth of the current generation.

Students should be exposed to educational approaches that encourage innovative thinking and critical thinking. Therefore, the need for playing in an educational setting for the intention of learning and growth needs to be practised more in conveying education to them. The effect of game-based learning style will not only let them develop and strengthen their understanding, it is also enjoyable and strives for healthy competitiveness in students as the nature of a game is. Liu, Zaffar Ahmed, and Gazizova (2020), express that in their findings of using game-based learning, the students display high levels of participation, curiosity, and also motivation toward their learning process. Therefore, as a result, numerous articles have been released containing assembled applications in various areas, their viewpoints including

opportunities, as well as constraints and factors regarding the circumstances in which they were studied.

Gameboard learning or also can be stated as tabletop game learning is an example of a game-based learning style that can be incorporated into nowadays teaching methods. The usage of bright colours and interactive style in the gameboard aids the student in maintaining their attention span on the game and helps them engage themselves in their learning lessons and build a concrete concept understanding in their mind. Meanwhile, Dimitra *et al*. (2020) clarifies that game based learning helps the students in a way which is more entertaining as the core contents and the objectives of the topic becomes more fun. Other than that, gameboard learning also offers experiential learning that may help in long-term memory development in the brain. Ali *et al*. (2017) explained action learning, learning by doing, learning through experience, and learning through discovery and exploration are all examples of experiential learning. Additionally, Foley (2020) explained the defining element of experience-based learning is that the learner's experience takes center stage in all aspects of teaching and learning. Thus all these researches highlighted the importance of game-based learning to be applied in classroom settings.

The content within molecular life science is inherently intricate, profoundly abstract, and deeply rooted with diverse disciplines (Tibell & Rundgren, 2017). The field of genetics, in particular, encompasses intricate terminology and specific concepts that students must initially grasp, but this proved to be a problem as the lengthy notes, as well as complicated terms

existing and used during class, hinder their ability to effectively engage with the topic. One of the topics listed in Genetic subject curriculum set by the university to be learned by Sultan Idris Education University, UPSI Biology students is Maternal effect (unpublished preliminary data). According to Schwabl and Groothuis (2010), maternal effect refers to the changes in progeny phenotype caused by the maternal phenotype.

This particular topic uses abstract concepts that are foreign to students, in addition to the whole concept of the topic is the opposite to mendelian concepts and understandings. Consequently, the assimilation of new information has proven to be challenging for these students. This difficulty in adaptation could potentially impede their full mastery of the conceptual knowledge, leading them to perceive the topic as arduous. Therefore, the primary objective of this research is to mitigate this issue by creating simplified instructional materials. These materials aim to facilitate students' comprehension of intricate terminology and concepts associated with the topic.

1.3 Problem Statement

The topic of Non-Mendelian Genetic is crucial to the field of genetics as understanding the pattern of inheritance that does not follow the simple pattern of Mendelian Genetics, will aid in understanding the complexity of genetic inheritance and identify genetic disorders. Although genetics in the context of education itself has been studied before (Asbury & Plomin, 2013; Banet & Ayuso, 2000; Jensen, 1972; Jolly, 2008), there has been lack of research done on the Maternal Effect topic itself.

Wright *et al*. (2022) elaborated on the topic molecular biology to be challenging to the learners due to biomolecules composed of DNA, RNA and protein, as well as biomolecular processes are not directly visible to the students. Maternal effect is related to molecular biology, and thus implies that this topic is highly difficult for students to learn. In a separate investigation, Wright *et al*. (2021) emphasised that students lacking a robust foundation in understanding a particular topic may encounter obstacles in mastering subsequent concepts. Consequently, it is imperative for students to acquire a comprehensive understanding of the maternal effect topic.

Students frequently encounter difficulty in comprehending concepts associated with gene expression. (Marbach-Ad and Stavy, 2000; Wright *et al*., 2014; Briggs *et al*., 2016; Southard *et al*., 2016). The subject of maternal

effect is intricately connected to gene expression. Maternal effect encompasses the transmission of maternal gene products, including mRNA and proteins, to the developing embryo. This process is closely intertwined with the regulation of gene expression. The comprehension of concepts related to inheritance, the nature of genes, and alleles poses challenges for learners, particularly younger students. Therefore, it is not surprising that numerous postsecondary students grapple with intricate processes such as meiosis, cell division, and genetics, as extensively documented by the research community in biology education (Wright, Catavero, & Newman, 2017).

Currently, based on preliminary study conducted, UPSI Biology students struggle to build their understanding of the base concept of Non-Mendelian Genetics specifically in the topic of maternal effect due to the difficulty of perceiving the concepts and terminology used. It is essential for these students to be able to comprehend because as a teacher-in-training, they would need to have the ability to relay the information to others. Figure 1.1 shows the Genetic results based on AT11 Biology students batch A201 achievement in the subject. Only 55 students are able to score grade A- and above while 4 students achieve grade C+, which is the minimum requirement to pass the subject, out of 125 students in total. Therefore, this shows that the average student taking the Genetic subject for batch A201 only has sufficient understanding of the topics in the Genetic curriculum instead of truly mastering the subject as a whole.

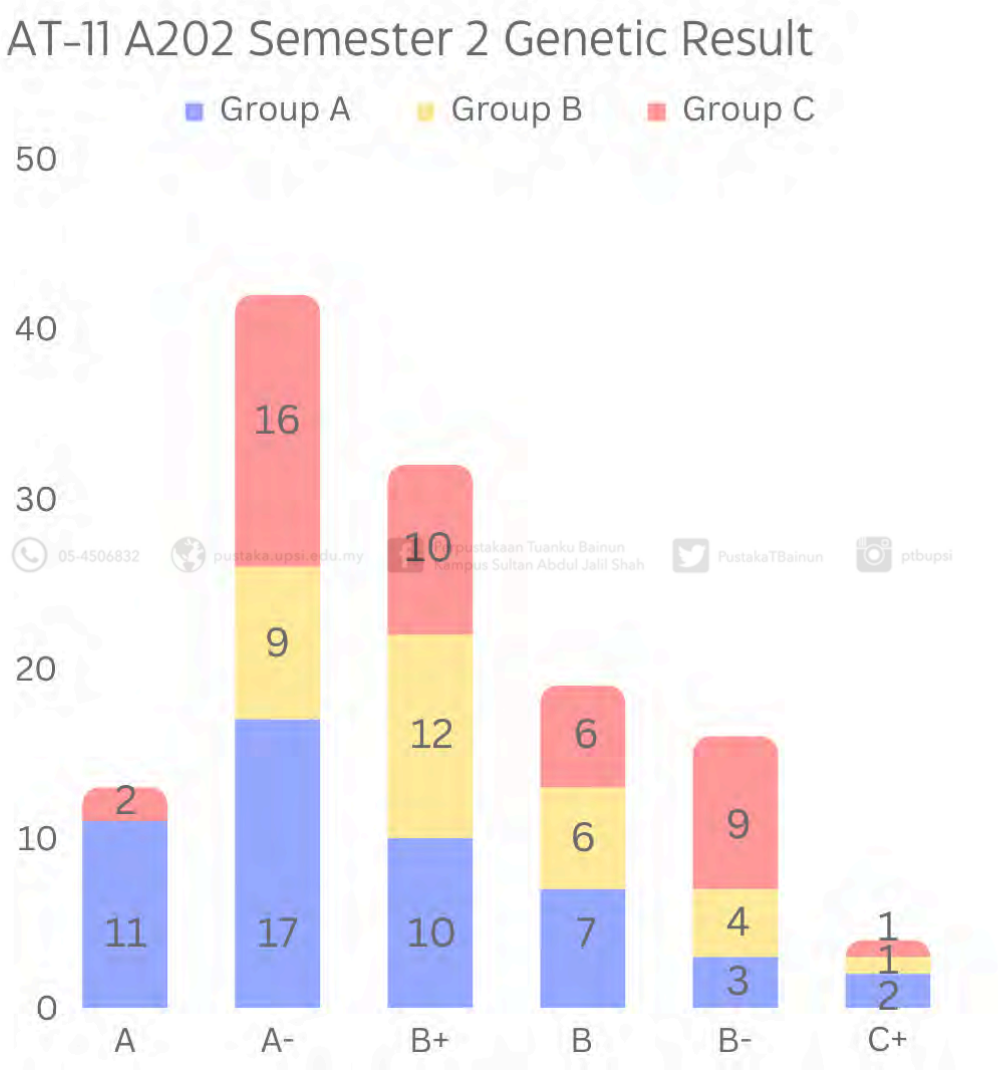

Figure 1.1: *Biology Major Students (AT11 A202) Genetic Result*

Firstly, to begin, the subject Genetic has arrays of topics with different contexts and factual information to be understood and memorised by biology students. This may result in the students facing difficulties in digesting information from some of the topics. The issue that exists in the subject Genetic, the topic of maternal effect, is the existence of complex concept mechanisms employed in the topic. Maternal effect highlighted the concept of the offspring phenotype to be dependent on the mother's genotype.

A pre survey had been carried out towards AT11 biology students to identify subjects that the students have difficulties to master. The result of said survey shows a big portion of AT11 students agrees that they find the Genetic subject has a variety of difficult words that challenges their understanding of the topics. For example, technical terms such as 'dextral coiling', 'sinistral coiling', and 'cytoplasmic inheritance' used in the topic of maternal effect are taxing for some students.

In addition, this can result in the students unwilling to explore the topic more and thus end up in them not having a full grasp of the subject. A previous study determined that students at the undergraduate level, enrolled in an introductory biology course, encountered challenges with the terminology associated with gene expression. Furthermore, they exhibited modest improvements in their comprehension of this subject matter (McDonald & Gomes, 2013). Thus since they are unable to understand the terminologies

used in the topic, they will face problems in mastering the knowledge of said topic.

A solution that can be done to solve this problem is that instead of using lengthy notes to be used as students' main source of class notes, less-worded flashcards could be used. According to Zuperly (2021), flashcards refer to little note cards where people can record information concisely on. Usually, the nature of flashcards is two-sided, with the prompt on one side and information regarding the prompt on the other. Flashcards are interesting and useful in academic purposes and settings to enable students to interact with knowledge in ways that improve memorization. They are purposefully designed to improve and encourage active recall.

According to Wissman, Rawson, and Pyc (2012) they found out that the top reason as to why students use flashcards is that it acts as a tool in order to assess the extent to which target knowledge has been learned and to aid in memorising information. Meanwhile, Lin, Daniel, and Toyatsu (2018) claimed that college students tend to use flashcards that are more detail-oriented which showed and highlighted the emphasis on definitions or facts related to a specific term. This is because detail-oriented flashcards will be of more help to these students to memorise better information due to the flashcards providing more comprehension and in-depth review of a topic.

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Next, another problem that arises among these students pertaining to the topic of maternal effect is that some of the students find the topic to be boring or they simply have low or no interest in studying this topic. According to Yang (2010), the rise of no interest in students are due to them not being able to relate the learning process to the real-world environment, viewing the topic needs to be learned as a job of memorising facts, and also emotional preferences in choosing what to learn instead of being confined in a fixed curriculum. In order to curb this problem, an interesting learning method needs to be brought forth. Using the same poll as previously, Preliminary Overview of The Difficulty of Subjects and Topics In The AT11 Program, the highest student vote for the suggested way to help solve the problem is game-based learning as mentioned in Figure 1.2.

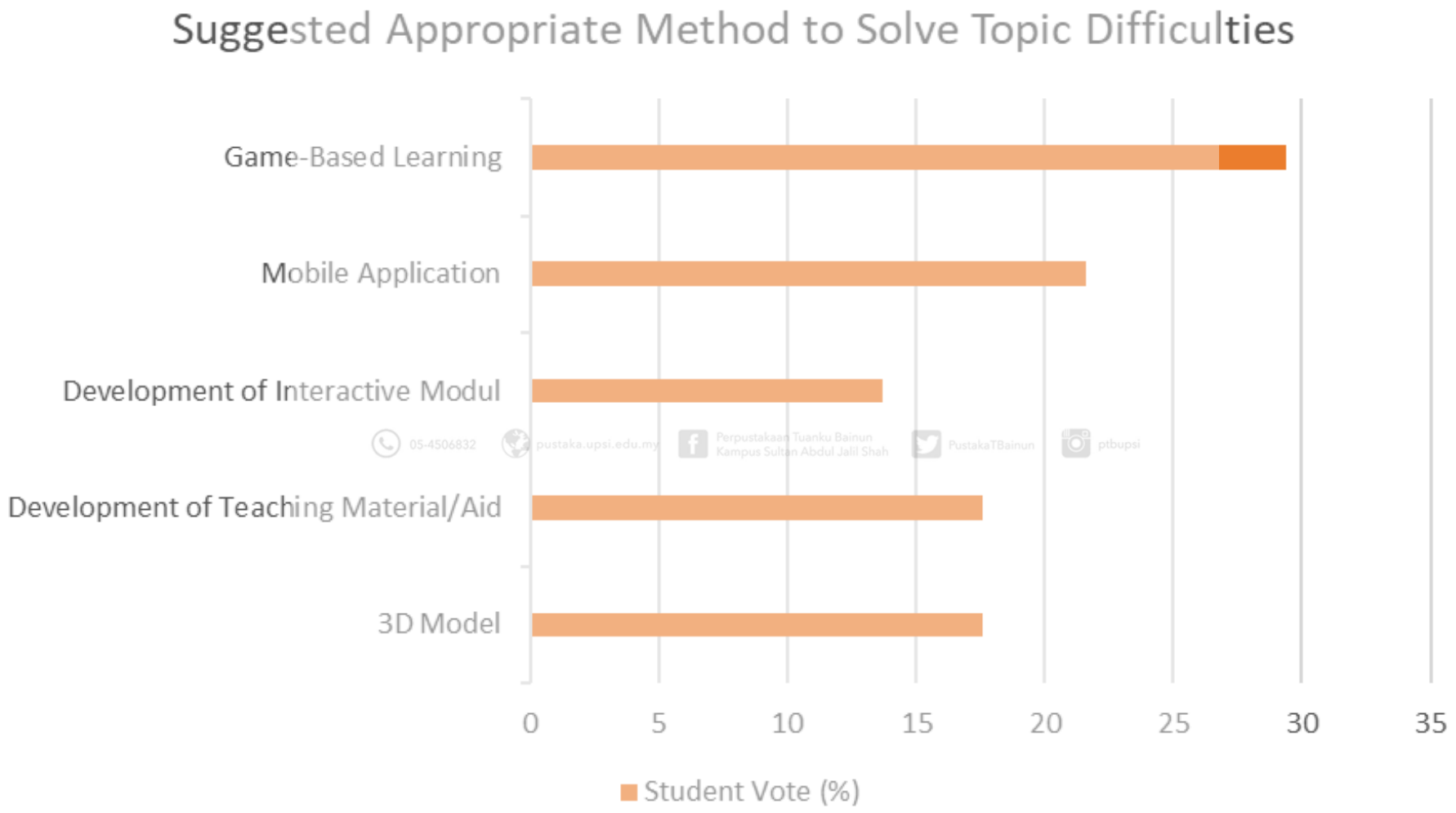

Figure 1.2: *Pre-Survey: Suggested Method to Solve Topic Difficulties*

Game-based learning offers an engaging environment for the students and thus increasing their interest in both the game and the topic learned at hand. According to Adipat *et.al* (2021), game-based learning can offer improvements in terms of the pupils' level of engagement, coordination, and creativity. The most obvious and compelling arguments for using game-based learning in the classroom are those that centre on student motivation and involvement. Therefore by applying game-based learning as teaching strategy in the classroom, students will feel more motivated to participate and become involved in the classroom, thus solving the issue of lack of interest in the topic.

Lastly, these biology students have problems in terms of lack of visualisation. While it is true that the lengthy notes and jargon of terms used proved to be an obstacle for the students, the insufficiency in the visualisation part also plays a role in becoming a problem to the students, mainly due to the presence of abstract concepts in this topic. According to (Dijkstra, Eerland, Zijlmans, and Post, 2014), the concept of abstract points to entities that have no physical or spatial limitations due to the concept having no direct representation in the physical world. Teaching and communicating about topics in this realm rely heavily on visual representations (Evagorou, Erduran, & Mäntylä, 2015).

Genetic is a subject that highlighted on the presence of genes and heredity and in which how these are passed down from parent to offspring (Poczai & Santiago-Blay, 2022), hence the absence of media for visualisation makes it difficult for students to comprehend further on the topic of Maternal effect and make sense of the abstract side of this topic. Tibell and Rundgren (2010) explained that undergraduate students lack proficiency in visual literacy comparable to that of experts. The pre-existent media that may act as visualisation for the student is insufficient, as showing only 'dextral coiling' and 'sinistral coiling' on snails instead of explaining how the genes are passed from the mother to the offspring that influences the offspring phenotype in detail.

Consequently, the utilisation of a more efficacious form of media or illustration becomes imperative to assist students who rely on visualisation, as well as those with a visual learning style, in comprehending the content of this topic. This assertion is supported by the research of Wright *et al*. (2022), which underscores that the mastery of visual literacy skills is interdependent with conceptual understanding within the discipline. For instance, incorporating media such as vibrant pictures or diagrams elucidating the transmission of alleles would suffice to facilitate understanding for these students. Visual aids depicting the mechanisms of coiling can also be integrated into teaching materials to enhance comprehension.

1.4 Objective

This study investigates the effectiveness of game-based learning in helping students gain more understanding of Non-Mendelian genetics: maternal effect concepts. In this research, there are three objectives which are;

1) To develop MamaXGenius card game for the topic of Maternal effect in Genetic subject.
2) To evaluate validity of the developed MamaXGenius.
3) To evaluate perception in the terms of content, usability, playability and satisfaction for MamaXGenius card game for the topic of Maternal effect in Genetic subject.

1.5 Research Question

In this research, there are three research questions which are;

1) How is the MamaXGenius card game being developed?
2) What is the validity of the MamaXGenius card game?
3) What is the students perception on MamaXGenius card game in terms of content, usability, playability and satisfaction?

1.6 Conceptual Framework

The conceptual framework to be used in this study is as Figure 1.3. This study underlines the utilisation of the ADDIE model in the instructional design model as well as the learning theory which is the cognitive theory, constructivism learning theory and theory of multimedia learning.

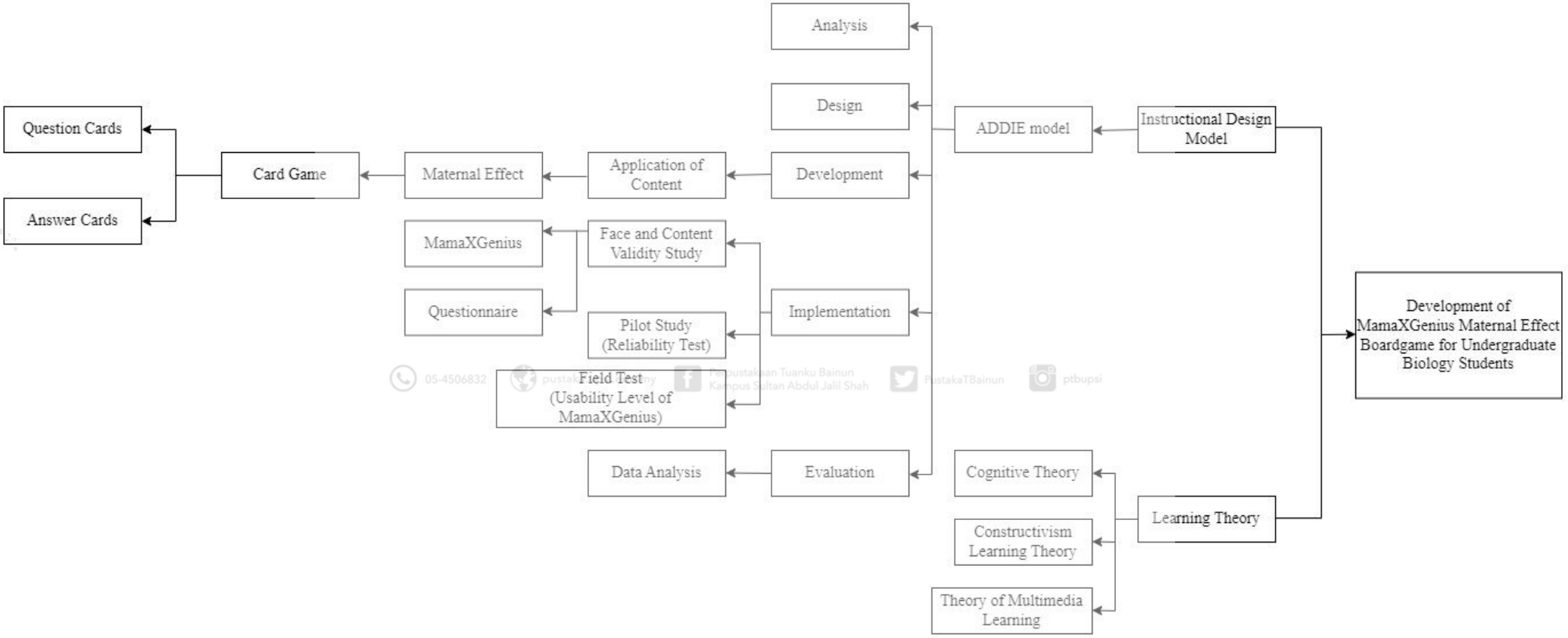

Figure 1.3: *Conceptual Framework*

ADDIE model is used in this study in order to produce a systematic foundation for the game board 'MamaXGenius' that is designed. This model consists of 5 processes which are made up of analysis, design, development, implementation, and evaluation. Debell (2020) stated that the ADDIE concept is broad enough to be applied to any form of learning experience for any audience. Meanwhile, M.Almelhi (2021) stated that when the ADDIE model is applied, the model demonstrates to have produced a successful outcome in his study on the increase of skills in creative writing among students. The model starts out with an extensive analysis followed by the process of designing, developing, implementing, and evaluating. Meanwhile, this research underlines three theories which are cognitive theory, constructivism learning theory and also theory of Multimedia learning. These theories were embedded in the card game through the developed questions and answer cards.

1.7 Operational Definition

This study proposes the creation of an educational board game for biology university students on Genetic subject pertaining to the topic of Maternal effect and thus will use a few keywords. Words like educational game board games, usability, fundamental concept effect, and development are the fundamental concepts used throughout this study.

1.7.1 Educational Board Game

In this study, a board game indicates a game played by a set of guidelines while played face-to-face by a number of players at a time. Hanus and Fox (2015) explained that an educational board game can be defined as a tangible,

interactive learning tool specifically designed to facilitate educational objectives and engage players in the acquisition of knowledge, skills, or concepts. These games often incorporate a combination of rules, challenges, and strategic elements, creating an immersive and enjoyable environment for learning in various academic subjects. Educational board games are those that are made to help students learn about specific topics, broaden their concepts, and also reinforce learning while the students have fun using the board game.

1.7.2 Development

In this study, development is a concept that creates growth, progress and positive changes in a component which applies to the product, educational board game. Zagal, Rick, and Hsi (2006) defined development as the systematic process involving the conceptualization, design, prototyping, playtesting, and refinement stages undertaken to create a playable and engaging board game. The development of MamaXGenius involved the ADDIE model as instructional design model consisting stages of analysis, design, development, implementation and evaluation.

1.7.3 MamaXGenius

In this study, the term MamaXGenius refers to a. educational card game that has been developed as a learning aid for the topic of maternal effect in the Genetic subject. Educational games refer to games employed in educational settings to facilitate and enhance the learning process (Sukerti & Pudjawan, 2021). MamaXGenius card game incorporated the terms and concepts of Maternal effect into the question and answer cards.

1.8 Research significant

This study aims to develop an educational board game for biology university students for the subject Genetic, pertaining to the topic of Maternal Effect. No formal or previous studies on the usage of game-based learning on the topic of maternal effect in Genetic subject have been undertaken thus far. The major goal is to create an educational board game for maternal effect that can be used by students to strengthen their understanding of the base concepts and factual information of the subtopic Maternal Effect, as well as to the educational state holder to be utilised.

The primary contributions of 'MamaXGenius' game card is in the game's ability to aid students in sharpening their critical thinking and problem-solving skills, and in return applying their knowledge in a practical context. The findings on this study will result in the disclosure of validity of the MamaXGenius card game to the topic Maternal Effect in Genetic. The results will prove useful to be used as a measuring tool to see whether 'MamaXGenius' card game may be used in an educational setting.

1.8.1 Students

The study offers findings that will be crucial in resolving the students' struggle on the topic of maternal effect among UPSI Biology students. Students can benefit from this board game to build a strong base understanding of the topic and also to reinforce the information on the topic themselves. Thus, will lead to a better grasp of the topic concepts and ideas, which in turn will increase the

students confidence in tackling this topic and results in higher academic performance in the Genetic subject.

1.8.2 Academia

This study is beneficial to the lecturers to be used as a teaching strategy or method while conducting the lesson on the maternal effect topic.The findings in this study provide precious insights for guiding and informing lecturers of the usage of game-based learning in class, The game board may be used to prompt students in exploring their understanding of this specific topic, while the lecturer may act as supervisor in administering and overseeing the student's progress. Lecturers can allow students to be creative by allowing them to come up with their own answers and ideas through the usage of this board game.The game board also eases the lecturer's worry in making sure students are fully understanding the concepts applied to the topic of maternal effect in Genetic subject. Therefore, the lecturers are capable to achieve the learning objective regarding this topic.

1.8.3 Higher learning institution

This study contributes significantly to university institutions, as the improvement in student grades resulting from the utilization of the 'MamaXGenius' board game underscores the importance of incorporating game boards in the study of Genetics. This outcome is expected to generate interest within the broader educational community, including administrators and staff, highlighting the significance of employing game-based learning

strategies in educational settings. Consequently, this heightened awareness is likely to motivate the community to embrace and implement game-based learning approaches more widely.

1.8.4 Educational Stakeholder

This study holds significance for various educational stakeholders, including parents, educators, policymakers, and business committees. The 'MamaXGenius' educational board game possesses commercial value while serving as a valuable learning resource for students. Moreover, the card game can serve as a beneficial tool for parents supporting their university-enrolled children's studies, as parental involvement plays a crucial role in fostering elevated academic achievement. Consequently, the outcomes of this study offer benefits to all educational stakeholders involved.

1.9 Research Limitation

This study has a few limitations that might end up influencing the end results and conclusions of this study. Firstly, the educational board game will only be created for Genetic subject, the subtopic of Maternal effects for biology students. This study will not cover every topic in the Genetic subject syllabus but only towards the subtopic Maternal effects. After a proper survey had been conducted among UPSI Biology students, the subject Genetic had appeared to be the top three subjects that is hard to be understood by students, while the

topic of Maternal effect is the top topic that was chosen to be a significant problem for them as well.

Therefore, only the subtopic Maternal Effect will be given attention to in this study, instead of all the subtopics in the subject Genetic studied by biology students. There is also no previous research done on the topic Maternal effect, regarding game-based learning that had been applied to this topic. Thus, this study aims to fill in the research gap that exists on this subtopic Maternal effect in the subject of Genetic.

The second limitation to this study is that only a small part of biology student population had been considered as population sample which is only among Sultan Idris Education University Biology students batch A201 that took part in this research as the sample. According to McNeish and Stapleton (2014), models or experiments with limited sample numbers may converge into a solution and produces parameter estimates, however, the values may contain bias, which may affect the inferences in applied research. When the sample size is small, it is critical that researchers are aware of and acknowledge the possible untrustworthiness of the end result. The size of the sample is not sufficient enough for statistical measurement to be considered as representative of the whole population sample of higher education biology students in Malaysia.

No other biology students from other universities had been taken as samples for this study. Therefore, the result of the Subject Genetic being chosen as the top three hardest subjects to be understood as well as the subtopic Maternal effect being the top chosen subtopics that is difficult, may only remain true for the group of Sultan Idris University Biology students. There is also no possibility to incorporate all biology students in higher education as the population sample, on factors of time and also energy limitation, therefore only UPSI Biology students in batch A201 are chosen.

1.10 Summary

In conclusion, this study highlights the usability of 'MamaXGenius' tabletop game as game-based learning in the subject Genetic, the topic of Maternal effects on UPSI Biology students batch A201. This study is important to help teacher-in-training and students alike to be prepared and understand the basic concept in addition to terms and factual information that existed on the topic of Maternal Effect. The usage of 'MamaXGenius' as learning aid will be able to help the lecturers to assist teacher-in-training and students to be able to grasp the concept of this topic that is viewed as a matter that is difficult to comprehend easily.