DEVELOPMENT AND PERCEPTION OF THE "GENETIC HOLIC" DIGITAL GAME APPLICATION AMONG BIOLOGY EDUCATION UNDERGRADUATE STUDENTS

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UNIVERSITI PENDIDIKAN SULTAN IDRIS,

MALAYSIA

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DISSERTATION SUBMITTED IN FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE IN EDUCATION (BIOLOGY)

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FACULTY OF SCIENCE AND MATHEMATICS

DECLARATION OF ORIGINAL WORK

This declaration is made on the 02 March 2024.

i. Student's Declaration:

I, PHOON YAN QI (D20201095397) hereby declare that the Final Year Research Project Report entitled DEVELOPMENT AND PERCEPTION OF THE "GENETIC HOLIC" DIGITAL GAME APPLICATION AMONG BIOLOGY EDUCATION UNDERGRADUATE 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.

Sincerely,
Signature of the student

ii. Supervisor's Declaration:

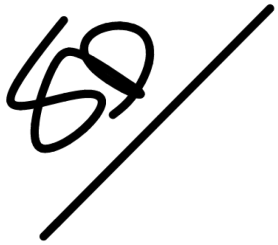
PROF. MADYA DR. SHAKINAZ BT DESA hereby certify that the work entitled DEVELOPMENT AND PERCEPTION OF THE "GENETIC HOLIC" DIGITAL GAME APPLICATION AMONG BIOLOGY EDUCATION UNDERGRADUATE

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

4-3-2024

Signature of the Supervisor



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ABSTRACT

The misconceptions on genetics topics among teachers and students were common, resulting in declining interest among the young generation in the STEM field. The study research questions consist of four which are to measure the face and content validity of "Genetic Holic", a digital game application on genetics topics, as well as the perception level of UPSI Biology undergraduate students regarding the engagement and motivation level on it. The product development was based on the ADDIE model. The S-CVI/UA for the product is 0.93 and the instrument is 1.00 while the percent of the agreement for the product is 96.15% and the instrument is 100%, where all the values can be interpreted at a very good level. The perception level of 165 UPSI Biology Education undergraduate students ranging from semester 3 to 7 toward the learning experience on "Genetic Holic" in the engagement and motivation aspects was evaluated in the 4-point Likert scale with stratified sampling method as the indicators for the usability of "Genetic Holic". The pilot test with Cronbach's alpha score yields a high reliability with a value of 0.842. The field test was conducted with descriptive quantitative analysis with the mean and standard deviation, yielded a result with a mean and standard deviation of 3.28 and 0.54 for the engagement aspect, 3.28 and 0.55 for the motivation aspect, representing a high-level perception among respondents. In conclusion, the great level of face and content validity for "Genetic Holic", furthermore the high perception of engagement and motivation. This implies that, it can be used as an effective learning tool, that helps to improve the understanding and leverage the interest of students in genetics learning.

PEMBANGUNAN DAN PERSEPSI APLIKASI PERMAINAN *"GENETIC HOLIC"* DALAM KALANGAN PELAJAR SARJANA MUDA PENDIDIKAN BIOLOGI

ABSTRAK

Salah konsep mengenai topik genetik dalam kalangan guru dan pelajar adalah perkara lazim, ini telah menyebabkan penurunan minat generasi muda dalam bidang STEM. Persoalan kajian terdiri daripada empat iaitu mengukur kesahan muka dan kandungan *"Genetic Holic",* iaitu aplikasi permainan digital mengenai topik genetik, serta tahap persepsi pelajar prasiswazah Pendidikan Biologi UPSI mengenai tahap penglibatan dan motivasi terhadap produk. Pembangunan produk ini adalah berdasarkan model ADDIE. S-CVI/UA bagi produk ialah 0.93 dan instrumen ialah 1.00 manakala peratus persetujuan pakar ialah 96.15% dan instrument ialah 100.00%, di mana semua nilai ditafsir sebagai berada dalam tahap yang sangat baik. Tahap persepsi 165 pelajar prasiswazah Pendidikan Biologi UPSI dari semester 3 hingga 7 terhadap pengalaman pembelajaran "Genetic Holic" dalam aspek penglibatan dan motivasi dinilai dalam skala Likert 4 mata dengan kaedah persampelan berstrata sebagai indikator bagi kebolehgunaan "Genetic Holic". Kajian rintis menunjukkan tahap kebolehpercayaan yang tinggi dengan skor Cronbach's alpha sebanyak 0.842. Ujian lapangan dijalankan dengan analisis kuantitatif deskriptif menggunakan min dan sisihan piawai, di mana min dan sisihan piawai ialah 3.28 dan 0.54 bagi aspek penglibatan, 3.28 dan 0.55 bagi aspek motivasi, menunjukkan persepsi responden berada dalam tahap tinggi. Kesimpulannya, tahap kesahan muka dan kandungan yang tinggi untuk *"Genetic Holic*", tambahan pula dengan persepsi yang tinggi terhadap penglibatan dan motivasi. Ini memberi implikasi bahawa ia boleh digunakan sebagai bahan bantu mengajar yang berkesan, dengan meningkatkan pemahaman dan minat pelajar terhadap pembelajaran genetik.

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SDGs	Sustainable Development Goals
STEM	Science, Technology, Engineering and Mathematics
ADDIE	Analysis, Design, Development, Implementation and Evaluation
ICT	Information and Communication Technology
MOSTI	The Ministry of Science, Technology and Innovation
GBL	Game-based Learning
DGBL	Digital Game-based Learning
UPSI	Universiti Pendidikan Sultan Idris
CVI	Content Validity Index
S-CVI/UA	Scale-level Content Validity Index Based on the Universal Agreement Method
S-CVI/Ave	Scale-level Content Validity Index Based on the Average Method
I-CVI	Item-level Content Validity Index
Edu@Innovate	International Education Innovation Expo
UniKL	Universiti Kuala Lumpur
SPSS	Statistical Package for the Social Sciences

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Sustainable Development Goals (SDGs) are shared blueprints for all the nations that target a better future for mankind all over the world. The 17 goals are hopefully to be achieved shortly. As one of the global partnerships, Malaysia plays an important role in taking the initiative toward all the goals, and the key is providing a quality higher education.

Higher education in the science, technology, engineering, and mathematics (STEM) fields is the important indicator to evaluate the nation's competitiveness in the aspect of technology and productivity. The motivation among students to achieve self-regulated learning is essential to improve their understanding of the topic in terms of academic achievement, and to elevate the nation's competitiveness. All the teachers in higher education must fulfill the ability for the reformation of Malaysia's educational system to be student-centered for an active learning pedagogical approach and making

use of the information and communication technologies (ICT) that make no barrier worldwide to quality education. Hence, the motivation and interest of students in the STEM field can be sparked through a pleasant learning experience, and indirectly they may try to practice self-regulated learning and continue to pursue STEM-related careers as their goal in the future. Former Minister of Higher Education, YB Dato' Seri Mohamed Khaled Bin Nordin, in the new year's message in 2023, also mentioned that the students have to be "smart and sharp" where the "smart skills" obtained through the co-developed with other humans while "sharp skills" are co-developed with computers.

1.1.1 Problem Faced in Malaysia Biology Education

The research found that teaching biology topics in a conventional method that is teacher-centered and face-to-face may lower the student's interest in biology. This is because the conventional lesson is unable to fulfill the needs of learning for students by having a visible view on genetics concepts (Christopoulos *et al.,* 2023). The topic of genetics had always been an issue that was hard to tackle in the Biology education process. The reason is not only due to the nature of the genetic topic but also closely related to the teacher's teaching approach and the student's willingness to study the topics (Machová & Ehler, 2023).

In a study among 75 pre-university students of Universiti Malaysia Sabah, the genetics-related topic is considered hard for them because of the conventional teaching

pedagogy of teachers (Matawali, 2019). This is because conventional teaching that only focuses on verbal and word expression in the teaching and learning process is not effective enough to illustrate the abstract and complex nature of genetics topics. Hence, the conventional teaching pedagogy had to be replaced with other pedagogy that was found more suitable in this context such as the student-centered teaching pedagogy which caters for the needs of various learning styles among students.

The conventional teaching approach results in a great decrease in students' motivation and engagement, thus lowering their interest in learning in Biology. According to the Education Ministry's 2020 Annual Report, 47.18% of students in STEM, and targeted to be increased to 60%, as mentioned by the Ministry of Science, Technology and Innovation (MOSTI). The lack of motivation and engagement among students in the genetic topic results in the decrease of genetic-related experts in Malaysia and may affect the progress of attaining the goals of SDGs.

1.1.2 Possible Strategies to Cope with the Problem Faced

Games have been claimed as an important field in human culture and society that encourages motivation and engagement (Bozkurt & Durak, 2018). The digital game is one of the best ways to teach and learn STEM subjects for 21st-century learners (Dadure *et al.,* 2021; Ishak *et al.,* 2021). The game application caters to the engagement of all students. Thus, they will find the learning process more interactive and attractive,

indirectly increasing their learning motivation after class. Consequently, students can perform well in the field of STEM.

1.2 Background of the Study

To support the running of "Malaysia Education Blueprint 2023-2025", all educators are encouraged to leverage ICT for learning to ensure high-quality teaching and learning experiences. With the generalization of computer and laptop devices among students, Digital Game-based Learning (DGBL) will be more achievable and widespread as a common teaching and learning aid for students.

Despite many of the studies with the results of gamification help to achieve learning outcomes such as elevating motivation (Bozkurt & Durak, 2018; Stuart *et al.,* 2020), learning achievement (Lo & Hew, 2020; Zamzami Zainuddin *et al.,* 2020) as well as the training process (Larson, 2020), however, there is still some opposition to studies that do not support the claim (Koivisto & Hamari, 2019). Thus, the study is targeted at testing the effectiveness of digital games in the context of education.

The "Genetic Holic" digital game application aims for users of Biology education students at the university level to have an overview of pre- and post-knowledge about the understanding of genetics topics. The digital game app was designed with a framework that includes a storyline, a series of quizzes, and a reward

system to increase the student's engagement in the learning process, and indirectly perform better in the genetic topics with a greater understanding.

1.3 Problem Statement

It was revealed that the topic of genetics is one of the most difficult topics for students in Malaysia (Wan Nasriha Wan Mohamed Salleh *et al.,* 2021), and the neighboring country which is Indonesia (Ahmad Fauzi, & Mitalistiani, 2018). Another survey study also supports the validity of the claim that 8.81% out of 568 students and 24 biology teachers in senior high schools in Indonesia, ranked the fourth hardest topic in biology education (Hadiprayitno, Muhlis, & Kusmiyati, 2019).

According to the survey among students of Biology Education at STKIP Persada Khatulistiwa Sintang, Indonesia, 85 % of students, in general, were only able to understand monohybrid cross but not dihybrid cross, meaning that the students generally cannot distinguish Mendel's laws I and II (Hilarius Jago Duda, 2016). Besides, in the research of science foundation students of the University Malaysia Sabah, 47.4 % out of 95 students had difficulties solving at least one of the given problems related to monohybrid cross and two dihybrid cross cases (Fadzilah Awang-Kanak *et al.,* 2016). The studies made things clearer that students are unable to master the topic of Genetics in the field of hybrid crosses.

Research also found that above 50% of high school teachers in Indonesia had misconceptions about genetics topics such as the relationship of DNA, genes, chromosomes, causes of mutations, and so on (Ika Sukmawati & Karunia Galih Permadani, 2020). Therefore, it is apparent that the misconceptions of teachers will fail students to understand the topic of genetics, giving a wrong conception for students that genetics is difficult to learn. In consequence, a useful learning tool that encourages active learning must be developed to tackle all the problems faced by Biology education students in the genetics topic. This is because the conventional talk and chalk teaching approach was less effective in reducing the achievement gaps among underrepresented students in STEM courses as a comparison with the active learning teaching approach (Theobald *et al.,* 2020). Therefore, the implementation of innovative and creative student-centered teaching methods can be practiced with appropriate teaching aids.

A preliminary study of 23 secondary school students in Malaysia also found them to have low STEM interests due to a lack of engagement and motivation. The introduction of a digital game with interactive graphics can be an effective solution to increase the engagement and motivation of students (Lina Mursyidah Hamzah *et al.,* 2022). According to the descriptive statistics from a 4-point Likert scale survey on the students who like learning science, the eighth-grade students of Malaysia have an overall agreement of 1.69 and 1.84 for the statement “I wish I did not have to study science” and “Science is boring” respectively. It shows that the motivation of students had to be leveraged to make the Biology learning process more enjoyable through the active learning approach such as game-based learning (Lay & Chandrasegaran, 2016).

From the above, the problems found in genetics learning and study are that the genetic topic is considered a hard topic, misconceptions of the genetic concepts occur as well as low motivation and engagement levels among the students. As a solution to the problem, the digital game app named “Genetic Holic” was developed. The features of the “Genetic Holic” were designed to tackle all the problems stated, such as the application of gamification elements and reward systems to increase the motivation and engagement level among students when learning genetic topics. At the same time, the game will give immediate feedback on the learning by looping the same question until the user gets the correct answer and comes up with a complete explanation after each question. The collection for the perception level of UPSI Biology Education undergraduate students’ learning experience on the “Genetic Holic” is vital to determine if the game could achieve the targeted goals. The value of face and content validity of both the product and instrument will be evaluated to ensure reliability. Following that, the motivation and engagement level of the users will be taken into concern as the measures of the effectiveness of the product towards the goals of enhancing the teaching and learning process for genetic topics.

1.4 Research Objectives

This study was conducted to:

i. Develop a digital game app on genetics topics among UPSI Biology Education undergraduate students.

ii. Determine the perception level of UPSI Biology Education undergraduate students' learning experience on the "Genetic Holic".

1.5 Research Questions

In particular, the scope of the study leads to the following questions:

i. What is the value of "Genetic Holic" face validity?
ii. What is the value of "Genetic Holic" content validity?
iii. What is the engagement level of UPSI Biology Education undergraduate students' learning experience on the "Genetic Holic"?
iv. What is the motivation level of UPSI Biology Education undergraduate students' learning experience on the "Genetic Holic"?

1.6 Conceptual framework

The conceptual framework is divided into input, process, and output. One of the inputs for the research was focused on game-based learning (GBL) which was first introduced by Jean Piaget in 1962 that emphasized the significance of play in cognitive development. Digital game-based learning (DGBL), more specifically, is integrated in parallel with the technology boom in this advanced age. The "Genetic Holic" is aimed

to have positive feedback in teaching pedagogy as in DGBL with the features of gamification to leverage both the understanding and learning experience among the students.

The second input is the mastery learning model. This model was first outlined by Benjamin Bloom in 1968 to have corrective activities to help the students master the learning goals. One of the special features of the "Genetic Holic" is the repeated action of choosing the choices of answers until the students choose the right one. After answering each of the quizzes, students can look through the further explanations given to have a deeper understanding and strengthen their memory of the topic of genetics.

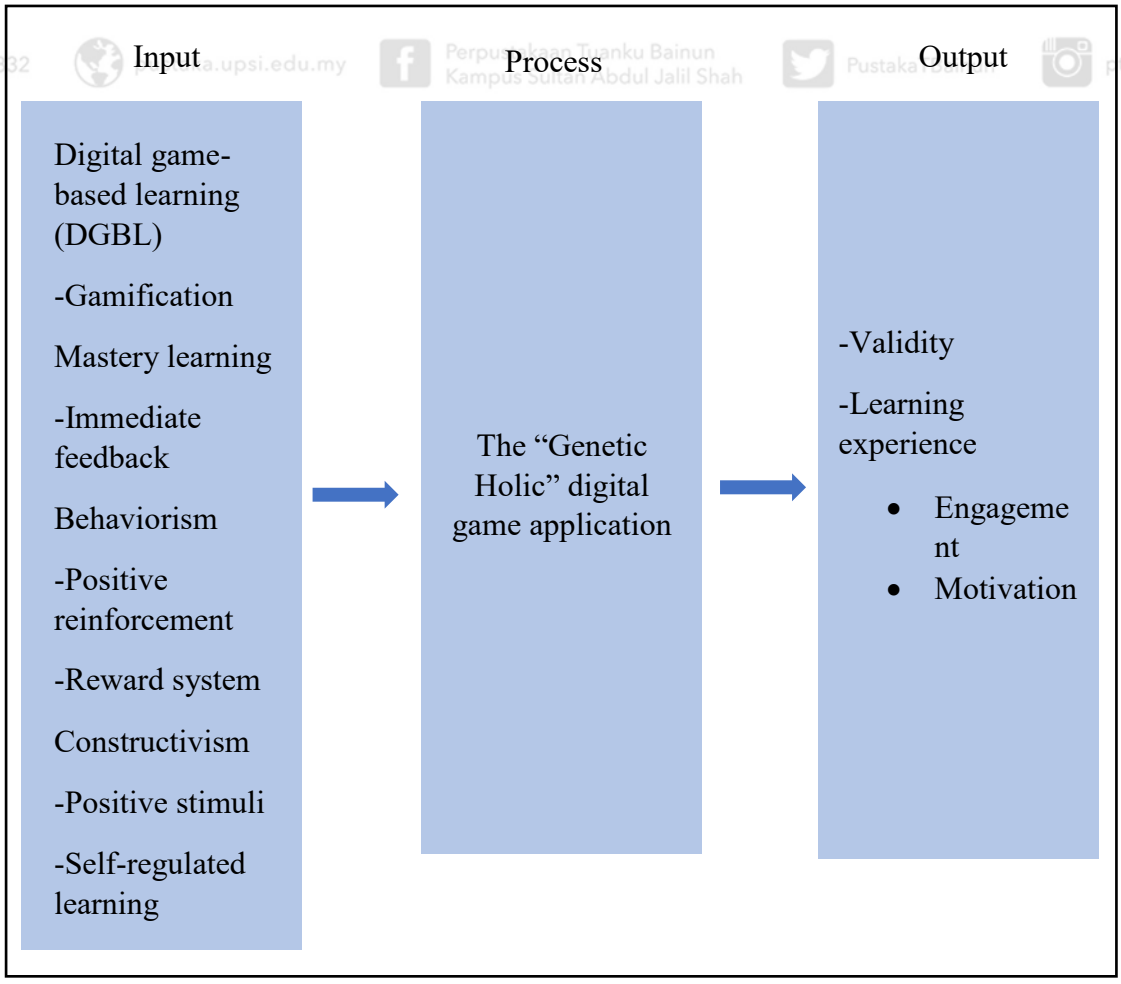
The third input is behaviorism learning theory. The theory of behaviorism is introduced by the B.F. Skinner 1938, a psychologist brings out the concept of environmental stimuli influencing the behavior of learners in either positive or negative ways (Skinner, 1938). The reward system specially designed in the "Genetic Holic" is an application of behaviorism theory with the expectation to increase the engagement of students and motivation with these achievable rewards.

The next is the constructivism theory proposed by Jean Piaget in 1964 (Piaget, J., 1964). The full engagement of students in the "Genetic Holic" is predicted to help them create a linkage between the previous knowledge and the new learning knowledge. The game experience will in turn reconstruct or modify their foundation of knowledge through the quizzes and simple notes on relevant genetics topics.

After the students use the "Genetic Holic" digital game application, the students are expected to have positive outputs in the aspects of validity and learning experience. The "Genetic Holic" will be evaluated by the experts to ensure the game application is of good quality for education needs and matched with the objectives. The learning experience of students can be divided into engagement and motivation aspects where both aspects can be elevated with the usage of the "Genetic Holic".

Figure 1.0

The Conceptual Framework of the Study



1.7 Significance of the Study

The development of the "Genetic Holic" digital game app is targeted to leverage the engagement and motivation of students in learning, or other words, to enhance the interest of students regarding the topics of genetics. Both Biology teachers and students may benefit from the "Genetic Holic".

1.7.1 Teachers

Biology teachers or lecturers in colleges or universities can recommend the students play the "Genetic Holic" as a revision to reconstruct the concepts of genetics such as the causes of mutations. Teachers can assign the quiz in the app as homework instead of the conventional writing test to get the student's feedback regarding the mastering of the topic. The reason is that the game elements make the learning process more engaging and fun, thus the students will tend to accomplish the test in the game app with the satisfaction of getting a reward rather than the traditional writing test given by the teacher.

1.7.2 Students

Biology education students can make use of the “Genetic Holic” to have a more interesting way to study the genetic topic. The interaction elements and storyline of the game are more engaging and make the students not easily distracted compared to the way of traditional reading and memorizing. Students can repeat the same quiz again and again, to further improve their mastering level regarding the topics and alert them to the progress of learning from time to time. The students will have a sense of satisfaction when accomplishing the task and feel motivated to study the genetics topic.

Overall, both the educators no matter the school teachers or lecturers in universities and the students may benefit from the “Genetic Holic”. In the aspect of teachers or lecturers, the gamification elements of “Genetic Holic” make it able to replace ordinary homework or assignments to encourage the accomplishment of students in a shorter time and higher learning effectiveness. On the other hand, the students can make use of “Genetic Holic” in self-learning without any assistance needed from the educators due to the clear instruction and comprehensive notes and quizzes of the game.

1.7.3 Society

The "Genetic Holic" sparked the interest of students in the genetics field to nurture more experts in a relevant field such as biological researchers, educators, etc. The motivation of students towards the Biology subject is a crucial key to letting them stay in the same Biology field in the career option which can in turn fulfill the worker's demand in the relevant field.

1.8 Scope and Limitations of the Study

The topic covered in the "Genetic Holic" only includes the genetic topic and mainly focuses on the subtopic of Genetic Variation and Mutation but not the other difficult topic for example Cell Biology, hence it helps students to increase their knowledge regarding only the genetics topic. Besides, it is unknown if there is a change in the perception level for undergraduate students to try the gamification learning method in other topics.

Aside from that, the respondents only involve the UPSI Biology Education students, therefore the category of the respondent's sample is considered specific but narrow in the variation. Thus, the results may not represent the big picture for all students in the colleges and universities of Malaysia. As a consequence, the field test

was carried out in online Google forms without a face-to-face session, therefore the gameplay experience was based on the credibility of the respondents.

1.9 Operational Definitions

1.9.1 Digital Game Application

The digital game application can be defined as a game that is structured to play with complete sets of rules, goals, and tasks for entertainment such as introducing the game elements for example levels, points, quests, and many more for engagement and problem-solving outcomes that can be accessed by digital devices such as computers, and mobile phone (Krat, Hürmann, & Von 2021). In this particular study, the digital game application is the application with gamification elements such as animation, graphics, sounds, quizzes, and a storyline that can entertain the users and at the same time achieve the educational purpose in genetic topics.

1.9.2 Perception

The term “perception” is defined as a process of an individual arranging and interpreting the sensations’ perceptions such as what they see, hear, or feel to define the surrounding environment (Setiadi Muhammad Astrianto, 2020). In this study, perception is defined as the impression of the Biology students towards their satisfaction level with "Genetic Holic” to give a sense of engagement and motivation in the genetic learning process. Hence, the development of survey items is based on the definition.

1.9.2.1 Engagement

Engagement can be defined as a series of goal-directed behaviors that cause deep involvement in learning activities to enhance the learning experience, deep learning, learning preference, and sense of participation (Ke *et al.,* 2015). In this study, motivation is more specific on the learning experience in terms of engagement, fun, deep, active and the focus level of users on the “Genetic Holic”.

1.9.2.2 Motivation

Motivation is the driving force for students that results in the continuity of learning activities in the aspects of learning time, willingness, and enthusiasm (Puspitarini, & Hanif, 2019). In this study, the motivation aspects emphasize the willingness of users to unlock all the quizzes in the "Genetic Holic", and also the curiosity towards the genetic topic.

1.9.3 Genetic Topic

Genetics topics can be divided into concepts and calculation parts. The topics involved are Mendelian Genetics which mainly focuses on the study of inheritance patterns based on the laws proposed by Gregor Mendel, DNA structure and function, genetic variation and mutation, genetic traits and inheritance, genetic disorders, genetic engineering and biotechnology, population genetics, human genetics, epigenetics, and lastly genetic ethics and social implications. Meanwhile, the calculations involved the Punnett squares, the probability of certain genotypes or phenotypes in a given cross in Mendelian Inheritance, allele frequencies, genetic crosses, and genetic mapping as outlined in the UPSI genetic course.

1.10 Summary

In short, students were addressed in many studies to have difficulties in learning the topic of genetics. As a result, DGBL through the digital game application known as the "Genetic Holic" is introduced to solve the problem. The "Genetic Holic" is expected to give a positive result for the learning experience of students by leveraging their learning motivation, engagement, and a sense of satisfaction throughout the learning process. Consequently, the problem of misconceptions and failure to understand concepts in genetics topics among students can be greatly improved and finally solved. The pros of the digital game app are shared among the population of teachers and students, and eventually the society. However, the study is not comprehensive enough and has some limitations as stated.