

DEVELOPMENT OF THE THREE-TIERS DIAGNOSTIC TEST AND STUDENTS' LEVEL OF UNDERSTANDING AND MISCONCEPTION IN GENETICS

NURHAZWANI BINTI MHOD SHUKRI

SULTAN IDRIS EDUCATION UNIVERSITY
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ABSTRACT

This study is aimed to develop a valid and reliable three-tiers diagnostic test in genetics. The study also aimed to assess pre-university students' level of understanding and misconception in genetics by utilising the developed test and to explore the misconception issue. It has employed a developmental design involving adaptation, validation and pilot study phase. The test named as Three-Tiers Diagnostic Test in Genetics (3-TDTG) consists of 15 questions was administered in the empirical study. Ten biology experts and 30 pre-university students were involved in the developmental phase, whereas 455 students of a matriculation college in northern peninsular Malaysia involved in the empirical study. Seven of them were purposely selected to be interviewed, along with six biology lecturers. The findings suggest the 3-TDTG to be valid with S-CVI values of 0.98 and 0.96 for face and content validity respectively. The false positive and negative value was minimised to 10.90% and 5.44%. Excellent construct validity was observed as Pearson correlation suggests a significant moderate positive relationship between the U2 and CS score, $r(453) = .44$, $p < .01$. Reliability of 3-TDTG is high with Cronbach's alpha value of 0.78, items' mean difficulty index of 0.37, and mean point-biserial correlation of 0.38. Students exhibited highest understanding on monohybrid inheritance and allele concept (U3=86.15%) while dihybrid inheritance recorded the highest misconception (M3=18.9%). The interview analysis suggests the misconception was due to complex genetics terminologies, complex application of multilevel thinking, dissociation of meiotic knowledge, memorisation and familiarisation, and poor internalisation of new concepts. To conclude, 3-TDTG is valid and reliable to assess students' genetics understanding and misconception, and the misconception issues were successfully addressed. Finally, the study has the implication on teachers where they can utilise 3-TDTG prior to the lesson for better lesson planning, while researcher can employ the test to expand the knowledge in wider scope.

PEMBANGUNAN UJIAN DIAGNOSTIK TIGA ARAS DAN TAHAP KEFAHAMAN DAN SALAH KONSEP PELAJAR DALAM GENETIK

ABSTRAK

Kajian ini bertujuan untuk membangunkan ujian diagnostik tiga aras dalam genetik yang sah dan boleh dipercayai. Kajian ini juga bertujuan untuk menilai tahap kefahaman dan salah konsep pelajar pra-universiti dalam genetik dengan menggunakan ujian yang telah dibangunkan serta meneroka isu-isu berkaitan salah konsep. Kajian ini mengambil rekabentuk kajian pembangunan yang melibatkan fasa adaptasi, kesahan dan kajian rintis. Ujian tersebut dinamakan Three-Tiers Diagnostic Test in Genetics (3-TDTG) mengandungi 15 soalan telah ditadbir dalam kajian empirikal. Sepuluh orang pakar biologi dan 30 pelajar pra-universiti terlibat dalam fasa pembangunan, manakala 455 pelajar di sebuah kolej matrikulasi di utara semenanjung Malaysia terlibat dalam kajian empirikal. Tujuh daripada pelajar tersebut dipilih untuk ditemubual bersama-sama enam orang pensyarah biologi. Dapatan kajian mendapati 3-TDTG adalah sah dengan nilai S-CVI untuk kesahan muka dan kandungan yang tinggi iaitu 0.98 dan 0.96. Nilai negatif dan positif palsu telah diminimakan pada nilai 10.90% dan 5.44%. Kesahan konstruk didapati cemerlang dengan nilai korelasi Pearson memaparkan hubungan positif signifikan yang sederhana antara skor U2 dan CS dengan $r(453) = .44$, $p < .01$. Kebolehpercayaan 3-TDTG adalah tinggi dengan nilai alfa Cronbach 0.78, purata indeks kesukaran item bernilai 0.37 dan purata korelasi point-biserial bernilai 0.38. Pelajar didapati mempunyai kefahaman tertinggi bagi konsep pewarisan monohibrid dan alel ($U3 = 86.15\%$), manakala pewarisan dihibrid merekodkan tahap salah faham tertinggi ($M3 = 18.9\%$). Analisis temubual mencadangkan salah konsep pelajar dalam genetik berpunca daripada terminologi genetik yang kompleks, aplikasi pemikiran pelbagai aras yang kompleks, kegagalan menghubungkan pengetahuan meiosis, hafalan dan kebiasaan, serta kegagalan memahami konsep genetik yang baru. Kesimpulannya, 3-TDTG adalah sah dan boleh dipercayai untuk menilai kefahaman dan salah konsep pelajar dalam genetik serta isu-isu berkaitan salah faham telah berjaya diutarakan. Implikasinya, guru-guru dapat menggunakan 3-TDTG sebelum pengajaran supaya pengajaran yang lebih baik dapat dirancang serta para penyelidik dapat memanfaatkan ujian ini untuk mengembangkan lagi pengetahuan dalam skop yang lebih luas.

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LIST OF ABBREVIATION

2-TDTG	Two- Tiers Diagnostic Test in Genetics
3-TDTG	Three- Tiers Diagnostic Test in Genetics
CRI	Certainty Response Index
CVI	Content Validity Index
DNA	Deoxyribonucleic acid
EPRD	Education Planning and Research Division
eRAS2.0	Educational Research Application System Version 2.0
I-CVI	Item CVI value
KSSM	Kurikulum Standard Sekolah Menengah
S-CVI	Sum CVI value
SDS	Sistem Dua Semester
SES	Sistem Empat Semester
SPM	Sijil Pelajaran Malaysia
SPSS	Statistical Package for The Social Science
STEM	Sciences, technology, engineering and mathematics

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Education in Malaysia is a dynamic system and progressively develops from time to time to meet the current global demand. This system has its core anchored firmly to the principles set in the National Education Policy and National Education Philosophy. It is worth highlighting one of the main goals of education in Malaysia as mentioned in the philosophy is to produce knowledgeable and competent Malaysian citizens which in return will contribute in the betterment of the nation.

In accordance to this notion, the matriculation programme in Malaysia has set its firm ground in providing quality education at pre-university level. This programme is aiming on developing students' potential, especially the Bumiputera, through a quality pre-university education which enables them to pursue their study at local or international higher education institutions in the science, technology and professional field (MOE, 2017). This aspiration is upheld by offering various pre-university courses

concentrated in the science, technology, engineering, and mathematics (STEM) for excellent SPM leavers.

Biology, among the other subjects is offered to matriculation students who aimed to pursue their study related to medical, health science, pharmaceutical, environment, and biotechnology, to name a few. In contrast with other science subjects, knowledge in biology is closely related to everyone's everyday life process. It discussed the living process such as respiration, digestion, senses, inheritance and many more. Hence, due to their interaction with the environment in their daily life, students tend to build their own conception related to biology. However, this conception might not align with the scientific explanation, thus will result in misconception (Verkade et al., 2017). Misconception is postulated to have its effect on students' learning. It is crucial for teachers to identify students' misconceptions so that effective lessons can be delivered. From the identification of students' prior ideas on the concept, teachers can tailor their teaching so that the misconception is rectified and eliminated consequently.

In the light of this issue, this current study is aimed to provide biology teachers with a comprehensive instrument to assist them in identification of students' misconception in biology subject, specifically in the topics of genetics. For the introduction, this chapter will shed some light on the background of the study followed by the statement of the problem and the conceptual framework. The purpose of the study together with the research objectives and questions will further set the direction of this study. Finally, the rationale, limitation and the operational definition of the study will also be discussed accordingly.

1.2 Background of Study

Matriculation programme in Malaysia is a pre-university programme whose establishment is out of concern of providing Bumiputera students with a solid foundation programme that enables them to pursue their study in tertiary education institutions with a central focus on the STEM field. In order to meet the current needs especially in the current industrial revolution 4.0 (IR4.0) era, the matriculation programme is continuously structured so that it stays relevant. To date, there are altogether 17 matriculation colleges throughout Malaysia which offer various STEM courses to SPM leavers.

The current programme structure in matriculation college consists of two systems which are Sistem Dua Semester (SDS) or Two Semester System and Sistem Empat Semester (SES) or Four Semester System (Matriculation Division MOE, 2019). Both SDS and SES programmes are mainly designed for science major while engineering and accounting are the other options offered in SDS programme only. Furthermore, the science major could be further grouped into three modules which are Module 1, Module 2 and Module 3. The description of the subjects taught in each module are as in Table 1.1.



Table 1.1

Offered subjects based on module

Module	Subjects
Module 1	Biology, Physic, Chemistry and Mathematics
Module 2	Physic, Chemistry, Mathematics and Computer Science
Module 3	Biology, Chemistry, Mathematics and Computer Science

The biology course is offered to students in Module 1 and Module 3 for both SDS and SES programmes. It comprises ten chapters in semester one and eleven chapters in semester two. The course is designed to equip students with adequate knowledge, together with critical thinking and problem-solving skills. In semester one, the syllabus mainly focuses on the topics of cells, biomolecules, inheritance, genetics and biological development. Whereas, in semester two the topics include transport system process, biodiversity, mechanism of adaptation of living things, ecological and also environmental issues. In addition, students' manipulative skills will also be developed during practical sessions throughout the whole programme.

Genetics concepts on the other hand underpinned most of the topics catered in matriculation syllabus. The distribution of genetics related concepts can be found in eight out of all chapters in the course. The topics include cell division, genetic inheritance, population genetics, expression of biological information, mutation, recombinant DNA technology, reproduction and speciation. Parallel with this fact, it is clear that the correct genetics conception is very crucial for students in order to master most of the biology topics.



However, as mentioned earlier, genetics or biology subject in general is prone for misconception as the nature of the knowledge is heavily related to one's everyday experience. Pre-existing idea or prior knowledge has a major role in knowledge construction as it will serve as the foundation and subject for modification by learners (Todd Hartle et al., 2012). It is believed that new knowledge cannot be formed on the wrong foundation (Sewell, 2002). Apart from everyday experience, knowledge about genetics has been formally introduced to students since secondary school. Cell division, reproduction, inheritance and genetic engineering are the topics included in the Kurikulum Standard Sekolah Menengah (KSSM) syllabus of form four and form five biology (Bahagian Pembangunan Kurikulum, 2018). Nevertheless, students' might develop misconception from their previous encounter of the topics and the misconception if not rectified immediately will interfere with their future learning of the concept.

1.3 Problem Statement

Genetics conception has become a topic of interest for many researchers back in the 1980s. A classic research by Johnstone and Mahmoud (1980) has identified genetics and water transport in plants were the topics that perceived high difficulty by students in Scotland. In 1999, they attempted to revisit their conclusion on this and surprisingly the difficulty on water transport in plants has resolved but not on genetics (Bahar et al., 1999). Since then, a lot of research has been conducted to address the issue. Knippels (2002) has summarised the main key of students' misconception on genetics. It includes



the usage of various terminologies, the mathematical content of the Mendelian genetic task, the involvement of the cytological process, the abstract nature of biology subject in the curriculum and the complex nature of genetics that requires multi-level thinking.

Although the work by Knippels (2002) addressed the issues that occur in the past, it is worth noting that the issues still persist in the current time. For an example, in term of language and terminologies, Osman et al. (2017) has reported students had difficulties to differentiate the term allele and gene while recently Buske and Bartholomei-Santos (2019) pointed in their study that students held erroneous view on the scientific concept of dominant and recessive allele. On a different note, Buske and Bartholomei-Santos (2019) also reported difficulties experienced by students in their attempt to solve conditional probability problem solving questions as it requires mathematical reasoning.

Furthermore, students were also reported to have weak understanding in meiosis process and often unable to relate the process with gametes formation in the genetic cross (Osman et al., 2017) and they often perceive meiosis and genetic inheritance as separate concepts (Fadzilah et al., 2016). Knippels et al. (2005) postulated this inability is due to the separation of these two topics (meiosis and Mendelian inheritance) in the biology curriculum hence contribute to the abstractness of the topic. Finally, the complex nature of genetics topics requires multi-level thinking from macro, sub-micro, and symbolic level contribute to the students' misconception. The macro level of thinking refers to physical observation of morphological character which is phenotype; whereas sub-micro thinking refers to the genotype which is the genetic make-up of the





physical characteristic; and these two levels are represent by letter symbol and require further interpretation by learners. This difficulty is reported in previous studies where some students failed to connect the concept of genotype and phenotype (Jalmo & Suwandi, 2018), genes and traits (Haskel-Ittah & Yarden, 2018), and also between gene, chromosome and DNA (Kılıç et al., 2016; Vlckova et al., 2016).

In local context of Malaysia, the similar genetics difficulties were also reported. Maimunah et al. (2014) has carried out research on form six students' misconception in genetics. Her findings suggested form six students had misconception in all of the genetics concepts tested in the two-tiers diagnostic test. At the same time, Fadzilah et al. (2016) carried out similar research but using three types of basic Mendelian genetics problems to be solved by the science foundation students in Sabah. From the findings she drew a conclusion that students had weak understanding on the concept of meiosis and Mendel's law of segregation.

Notwithstanding that there are a handful of research in this area, however it is unfair to generalised the result in Malaysian matriculation context where similar research is at scarce to date. Hence, a need analysis has been conducted in the current research to gain an overview on the issues and difficulties in biology teaching and learning at matriculation college (Appendix A). The need analysis consists of two parts; first, a survey among biology lecturers on their perception on the issues and difficulties in biology teaching and learning at matriculation college; and the second part is the analysis of students' performance in topical tests set by the college. The finding from the survey reported 75% of the biology lecturers agreed that genetic inheritance is the





topic that perceived as most difficult by students followed by the topic of cell division for 10.7%, and 7.1 % for both mutation and recombinant DNA technology. Most of them believed the main reason behind the difficulties is due to students' weak conception on the topic and it is well demonstrated through their weak performance in test. This finding is further supported by the analysis of students' performance in the topical test where students' average scores in the genetic inheritance topic was found among the bottom three of the weakest performed topics in the syllabus following the topic of molecules of life and cell structure and function, and in fact the lowest among genetics related topic.

On the other hand, 96.4% of the lecturers believed the importance of eliciting students' prior knowledge in resolving misconception issues. At the same time, they preferred the diagnostic test to be easy to administered for the classroom utilisation. From the review of past research on genetics misconception, there are various assessment tools being employed such as interview (Osman et al., 2017), open ended question (Jalmo & Suwandi, 2018), multiple-choice question test (Smith & Knight, 2012) and two-tiers multiple choice test (Tsui & Treagust, 2010; Maimunah et al., 2014).

Each assessment tool has its own advantage and disadvantage over one another. Compared to interview and open-ended questions, a multiple-choice question test is believed to be more favourable in terms of easy to administer and scoring (Gurel et al., 2015). The multiple-choice question can be either in the form of single tier or multiple-tiers. A multiple-tiers question is said to have better discrimination on students' score



as well as give better insight on students' cognitive structure. Two-tiers diagnostic tests can discriminate students' answers based on their reasoning but it cannot discriminate between the mistake due to lack of knowledge or due to misconception (Hasan et al., 1999). To overcome this limitation, a three-tiers multiple choice test is suggested by integrating confidence level after the answer and reasoning tiers (Caleon & Subramaniam, 2010a). In this way, the students' score will be further discriminated based on their confidence level and give better insight of students' level of conception. Despite of its effectiveness and sensitivity, the utilisation of three-tiers multiple choice test in assessing genetics misconception is limited although it has been employed in other biology discipline such as ecology and ecosystem (Arslan et al., 2012; Liampa et al., 2019; Oberoi, 2017), evolution (Helmi et al., 2019), and transport system (Ainiyah et al., 2018).

Providing all these facts, there is a significant knowledge gap that requires attention. The gap can be seen in two perspectives, first the needs of research on genetics understanding and misconceptions at matriculation college due to the findings of the need analysis, and second the lack of availability of three-tiers diagnostic instruments that fit the local context to assess genetics misconceptions. Combining these two, the current study is aimed to fill the knowledge gap by developing a three-tiers diagnostic test to assess genetics understanding and misconception among pre-university students at matriculation college and to explore the issue of the misconceptions with regards to local context.

1.4 Conceptual Framework

Theory of constructivism views learning as internalising new ideas or experiences into a complex system of individual's prior knowledge or experience (Todd Hartle et al., 2012). Hence, it is fair to mention that prior knowledge is critical in determining a successful learning. If the new idea opposes the prior knowledge, it will result in conflict that ends with misconception. In order to tackle the issue, it is best for educators or teachers to be able to identify students' misconception so that it can be rectified and ensure successful learning attainment.

In the light of the said idea, this study is aimed to develop a valid and reliable instrument to assess students' understanding and misconception in the topic of genetics specifically. The said instrument is referring to a three-tiers diagnostic test which is aimed to be adapted from a two-tiers diagnostic test in genetics (2-TDTG) by Tsui and Treagust (2010). The adaptation process of the instruments involves refining of the original items and addition of new items with respect to the local context of the study, and at the same time a Certainty Response Index (CRI) will be incorporated at the third tier of the items producing a three-tiers diagnostic test in genetics (3-TDTG).

As mentioned earlier, the development of the 3-TDTG is by adapting the 2-TDTG, hence similar theory and framework used in developing the 2-TDTG is retained. The original 2-TDTG was developed to test students' genetic reasoning and has its basis in the multiple-hypothesis theory proposed by Lawson (1992). The theory recognised



three types of reasoners which are novice, expert and advanced reasoner. Novice reasoners used mental representation on one antecedent condition to make a conclusion, while expert reasoner will use more than one antecedent conditions for drawing a conclusion. On top of that, an advanced reasoner is more reflective and seeking for alternative antecedent conditions and making inference before arriving at the conclusion. This theory as well as current matriculation biology syllabus will be used to formulate a test specification table which in turn will provide guidance in developing the items of the test.

In addition, the adaptation process will also include the integration of CRI as the third tiers of the test. The CRI has the ability to discriminate students' answers based on their confidence rating. Hassan et al. (1999) suggested the usage of CRI to distinguish mistake due to lack of knowledge and misconception. Hence, the sensitivity of the test will be increased at the same time overcoming the limitation exhibit by ordinary two-tiers test (Caleon and Subramaniam, 2010a).

Furthermore, it is important to determine the validity and reliability of the newly developed instrument. Validity refers to the ability of an instruments to measure what it supposes to measure (Cohen et al., 2007), while reliability refer to the ability of the instruments to produce consistent result over the usage on multiple occasions (Varma, 2006). There are few types of validity for a test such as content validity, face validity and construct validity. Content validity as described by Cohen et al. (2007) is a form of validity that focus on coverage and representativeness of the instruments in providing comprehensive coverage to the domains it supposes to cover. At the same time, face





validity is focussing on the appearance or the face value of the instruments as it is designed to test. Besides, construct validity of a test shows a clear relationship between the test item with the proposed concept, where the performance of the test can be explained by a particular concept. In the current study, both validity and reliability of the 3-TDTG are yield through a statistical data analysis of the data collected through survey method during the pilot study and empirical study.

In addition, the application of the 3-TDTG will be extended in larger scale in the empirical study where the data from the survey will be used to report the students' level of understanding and misconception across the three tiers of the test. The level of understanding can be seen in three perspectives which are i) correct answer on the first tier only regardless the reasoning and confident level, ii) correct answer with correct reasoning regardless the confident level, and iii) correct answer, with correct reasoning and certain answer. It is postulated that students who have the combination of correct-correct-certain as possessing a scientific knowledge, which is the highest level of understanding.

Similarly, the level of misconception is determined across the three tiers of the test which are i) incorrect answer on the first tier only regardless the reasoning and confident level, ii) incorrect answer with incorrect reasoning regardless the confident level, and iii) incorrect answer, with incorrect reasoning and certain answer. Students with incorrect-incorrect-certain responses will be classified as having misconception.





However, the finding from the survey method does not suffice to give insightful ideas on the issues of students' misconception in genetics. The issues behind each misconception needs to be further explored so that its nature and common pattern among the participants could be clearly outlined. Thus, a semi-structured interview with selected students having high misconception scores and a focus group discussion among biology lecturers are expected to yield meaningful discovery. The following Figure 1.1 summarised the conceptual framework of the current study taking into account the theory, variables as well as methods involved.

1.5 Purpose of The Study



The purpose of this study is to develop a valid and reliable instrument to assess students' genetics understanding and misconception known as Three-Tiers Diagnostic Test in Genetics (3-TDTG) by adapting the established Two-Tiers Diagnostic Test in Genetics (2-TDTG) by Tsui and Treagust (2010). The test will be developed in accordance to Malaysian matriculation syllabus within a specific context of genetic reasoning. The developed instrument is expected to undergo several tests to establish its validity and reliability. Consequently, the 3-TDTG will be administered to pre-university students at matriculation college in order to gain insight on their level of understanding and misconception in genetics. This research will be strengthened by conducting a semi-structured interview with the students and a focus group discussion with biology lecturers in order to gain in-depth and further understanding on the issues of misconceptions in genetics held by the pre-university students.



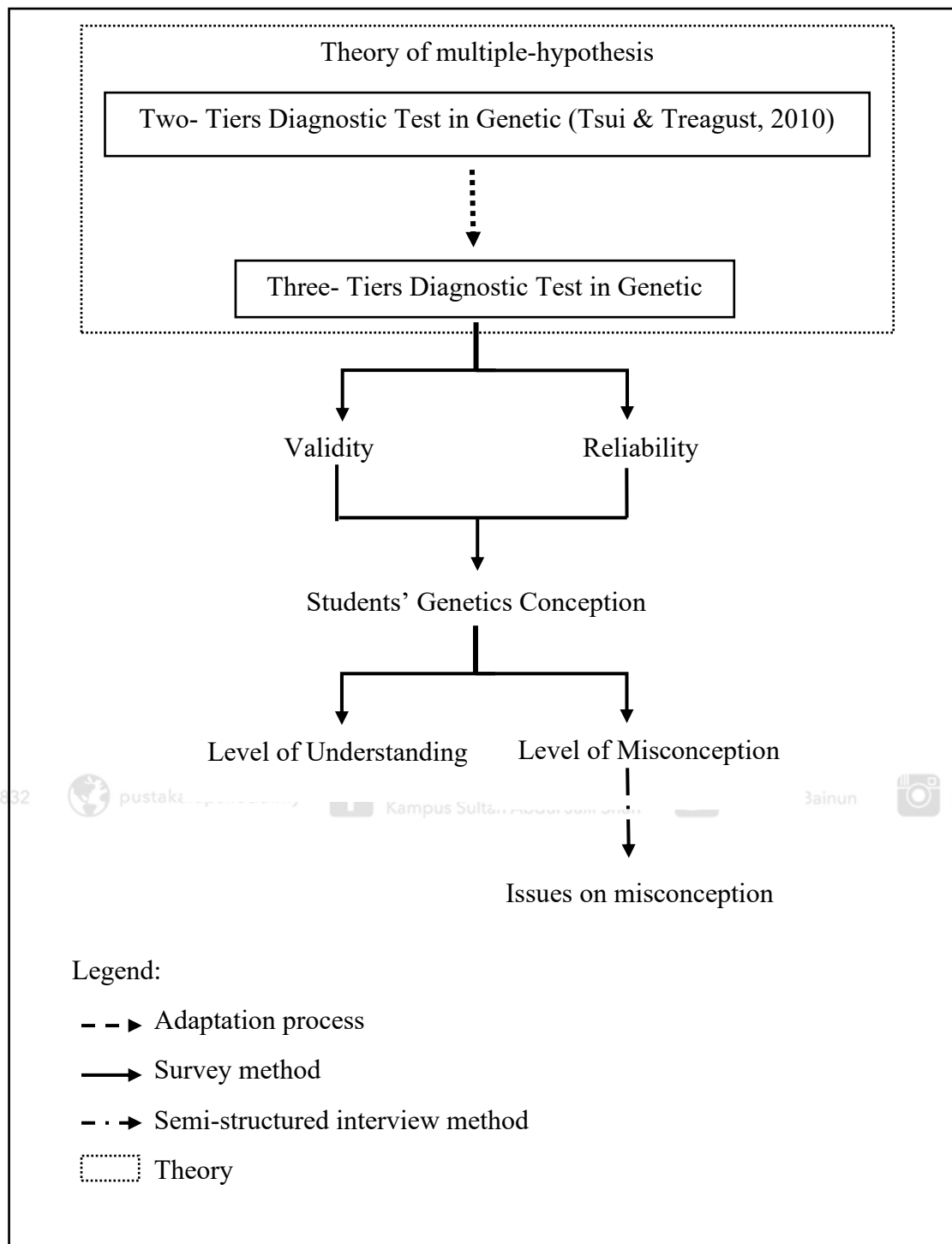


Figure 1.1. The conceptual framework of the study

1.6 Research Objectives

The objectives of this research are outlined as the following:

1. To develop a three-tiers diagnostic test in genetics by adapting the Two-Tiers Diagnostic Test in Genetics.
2. To identify the level of pre-university students' understanding in genetics concept.
3. To identify the level of pre-university students' misconception in genetics concept.
4. To explore the misconceptions held by pre-university students on the genetics concept.

1.7 Research Questions

The research objectives stated earlier served as the basis in formulating the following research questions in this study. The research questions corresponding to each research objective are listed as the following.

- RQ1: Is the adapted three-tiers diagnostic test in genetics valid and reliable?
- RQ2: What is the level of understanding held by pre-university students on the genetics concept?
- RQ3: What is the level of misconception held by pre-university students on the genetics concept?

RQ4: How the issue of misconception exhibited by the pre-university students on the genetics concept?

1.8 The Rationale of The Study

This study is expected to produce a valid and reliable three-tiers diagnostic test for genetics as well as to offer knowledge on the level on genetics conception among pre-university student from its finding. It is also predicted the instrument and the finding of the study can be benefited by many in the related fields such as students, teachers, education ministry and also researchers.

For instance, teachers can utilise the instrument to test students' genetics conception so that they can elicit students' existing knowledge prior to their lesson. At the same time, the application of the test prior to the lesson will channel students' focus on the tested topic. This condition can be benefited by both parties concurrently, as teachers can tailor the lesson so that it can address and rectify students' misconception immediately, while students can experience meaningful knowledge acquisition.

On the other hand, the finding of the study might give a better insight for ministry of education especially in order to develop a biology syllabus that can minimised students' misconception in genetics that perhaps originate from the syllabus itself. And finally, the findings of the study can serve as the basis of future research by

other researcher whether locally or globally to further expand the knowledge in the field of research. The developed instrument in the current research will also made available for public use and hoped to contribute to the available diagnostic instruments in the field.

1.9 Limitation of The Study

This study exhibits some limitations. First, the adaptation process of the instruments will consider the nature of the original instrument. For instance, the development of the original items was confined within a specific genetic reasoning matrix. Thus, any changes on the items are confined within the genetic reasoning matrix. Secondly, as the population involved in the empirical study was pre-determined, thus the findings of the survey in current research is not meant to be generalised to the general population of pre-university students. To be exact the findings will only be reflecting the population involved in the current study which is the SDS students of one matriculation college in northern peninsular Malaysia.

Additionally, COVID-19 outbreak during the period of the study has imposed major limitation to the study where physical contact is prohibited. Thus, the research procedure has been tailored to fit the current situation and online medium was utilised fully in all research phase.

1.10 Operational Definition

There are few terms are being used to deliver the purpose of the current study. The following are the terms and its definition in the context of this study.

1.10.1 Diagnostic Test

Students' learning difficulties might be contributed by many factors including misconception. It is crucial for educator to employ an assessment tool to identify these issues prior to the lesson. A diagnostic test on the other hand, is defined as an assessment tool that are focusing on the persistent or recurring learning difficulties which are left unresolved and are the causes of learning difficulties (Gronlund, 1981, as cited in Gurel et al., 2015). In the current study, there are several types of diagnostic test has been addressed and discussed, but mainly focusing on the development and application of a diagnostic test named Three-Tiers Diagnostic Test in Genetics (3-TDTG) to identify students' misconception specifically in the topic of genetics.

1.10.2 Three – Tiers Diagnostic Test

There are several types of diagnostic test such as interview, open ended test, multiple-choice test and multiple-tiers test. A three-tiers diagnostic test is a type of multiple tiers test which every question in the test were developed in set of three tiers. The first tier includes an ordinary multiple-choice question, the second tier consist of multiple-choice question inquiring for the reasoning to the answer in the first tier, and finally the third tier consisting a scale asking for students' confidence level of the given answer (Gurel et al., 2015). Although the three-tiers diagnostic test developed in the current study took the similar general format, a slight modification was made on the third tier, where the scale of confidence level was simplified to a 'yes' and 'no' (indicating confident and vice versa) to reduce time consumption during the administration.

1.10.3 Level of Understanding

Generally, understanding can be referred as knowledge about a subject, situation or how something operates. With the respect of the current study, the knowledge under investigation is the genetics knowledge held by the pre-university students. The knowledge is bound in the scope of genetic inheritance concept outlined in the Malaysian biology matriculation syllabus that includes the concept of gene, monohybrid inheritance, dihybrid inheritance and also deviation cases of Mendelian inheritance such as linked genes, sex-linked genes and incomplete dominance. The



level of understanding of these concepts is measured by the implementation of the three-tiers diagnostic test developed in the study. It is represented by the percentage of correct response given by students in three different cases; i) percentage of all correct response in the first tier only, ii) percentage of correct response on first and second tier, and iii) percentage of correct response on first and second tier with certain at the confidence level. In other words, students are considered to possess understanding on the tested concept if they are able to give a correct answer for the question along with a correct reasoning while being confident with the answers given.

1.10.4 Level of Misconception



Suprpto (2020) defined misconception as a misunderstanding in linking a concept to other concepts, or between a new concept and the pre-existing concept already in mind which result formation of wrong concept. In the current study, students' pre-existing conception on genetics might rely heavily on their formal encounter of the topic during secondary school as genetic inheritance was first introduced in the Form Five KSSM syllabus. Apart from that, their own experience might also contribute to the development of the pre-existing knowledge on the concepts. As they further their study in matriculation college, the topic is again being taught and might revealed their misconception. Due to that, the utilisation of a three-tiers diagnostic test in the current study will enable the measurement of students' misconception based on their response across all three-tiers questions. The level of misconception is measured as the following; i) percentage of incorrect response for first tier only, ii) percentage of the





combination of incorrect response for first and second tier, and iii) percentage of incorrect response for both tiers with certain indication at the confidence level. To simplify, students will be identified as having total misconception if they are confident with the wrong answer given on tested concept with wrong reasoning as well.

1.10.5 Genetics

Genetics can be referred as one of biology discipline that focuses on the study of DNA, genes and heredity. In this study, the scope of genetics that is being tested is limited to the Mendelian inheritance concept. This is parallel to the fourth topic taught in matriculation syllabus named Genetic Inheritance. This topic has it focused primarily on the monohybrid and dihybrid inheritance along with the deviation case of Mendelian inheritance including multiple alleles, incomplete dominance, sex-linked genes, and linked genes.

1.10.6 Pre-University Students

Pre-university student in Malaysian context is an individual or students that pursue his or her study after secondary school prior enrolling into any tertiary education institution. In this study pre-university are referring to the 18 to 20 years old two-



semester system's (SDS) students from module 1 and 3 of one matriculation college in northern peninsular Malaysia.

1.11 Conclusion

To sum up, this chapter has outlined the core information of this research including the research background, problem statement, objectives, research questions, research rationale, limitation and the operational definition of the terms involved. The next chapter will be discussing the review of past literature to give deeper insight in this particular area of interest.