THE EFFECTIVENESS OF TRANSFORMATIVE EXPERIENCE WITH ANALOGY (TEWA) MODULE IN GENETICS AMONG STUDENT TEACHERS

RAVINTHERAN A/L KALIMUTHU

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by

RAVINTHERAN A/L KALIMUTHU

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CDC	Curriculum Development Centre
CG	Control Group
DC	Dick and Carey
DNA	Deoxyribonucleic Acid
EG	Experimental Group
EP	Expansion of Perception
EV	Experiential Value
GCDT	Genetics Concept Diagnostic Test
GMAT	General Model of Analogy
IPG	Institut Pendidikan Guru
MC	Misconceptions
MU	Motivational Use
NU	No Understanding
PU	Partial Understanding
PU/MC	Partial Understanding with Specific Misconceptions
SMT	Structure Mapping Theory
SPM	Sijil Pelajaran Malaysia
SPOCU.C	Sum of Post Test Conceptual Understanding for Control Group
SPRCU.C	Sum of Pre Test Conceptual Understanding for Control Group
SU	Sound Understanding
TEQ	Transformative Experience Questionnaire
TEWA	Transformative Experience With Analogy
TWA	Teaching with Analogy

KEBERKESANAN MODUL "TRANSFORMATIVE EXPERIENCE WITH ANALOGY (TEWA)" DALAM GENETIK DALAM KALANGAN GURU PELATIH

ABSTRAK

Tujuan utama kajian ini adalah untuk mengenalpasti kelaziman pengalaman transformatif dalam tajuk genetik melalui tiga aspek yang saling berhubung: penggunaan termotivasi; peningkatan persepsi; dan nilai pengalaman. Kajian ini juga bertujuan meneliti keberkesanan pengalaman transformatif dalam mengatasi masalah miskonsepsi dalam tajuk genetik dalam kalangan guru pelatih Program Pendidikan Sains Rendah di institut pengajian tinggi. Seramai 120 guru pelatih major sains dari empat Institut Pendidikan Guru Malaysia menyertai kajian ini. Kajian ini menggunakan rekabentuk kuasi-experiment di mana modul "Transformative Experience With Analogy" (TEWA) yang diubahsuai dari Glynn (2007) digunakan sebagai instrumen intervensi. Kedua-dua instrument kajian kuntitatif dan kualitattif telah digunakan. Instrumen kuantitatif terdiri daripada soal selidik "Transformative Experience" (TEQ), dan Ujian Diagnostik Konsep Genetik (GCDT) manakala instrumen kualitatif pula adalah temu bual separa struktur bagi menentukan miskonsepsi guru pelatih tentang konsep genetik. Pelbagai ujian deskriptif dan statistik digunakan bagi analisis data. Dapatan kajian menunjukkan bahawa kumpulan guru pelatih yang melalui intervensi TEWA menunjukkan pengalaman transformatif yang lebih tinggi dan mengalami perubahan konseptual yang menggalakkan berbanding kumpulan kawalan. Implikasi pemindahan pengalaman sebagai teknik pedagogi dalam perubahan pemahaman konsep turut dibincangkan.

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ABSTRACT

The main aim of the study is to identify the prevalence of transformative experiences in genetics in terms of three interrelated qualities: motivated use; expansion of perception; and experiential value. The study also aimed to examine the effectiveness of transformative experience in overcoming misconceptions in relation to the topic genetics among student teachers enrolled in a Primary Science Education Programme in institute of higher learning. A total of 120 student teachers majoring in science from four Teacher Education Institutes in Malaysia participated in this study. A quasi-experimental design was used where the Transformative Experience With Analogy (TEWA) module adapted from Glynn (2007) was used as the intervention tool. Both quantitative and qualitative research instruments employed in this study. The quantitative instruments were the Transformative Experience Questionnaire (TEQ), Genetics Concept Diagnostic Test (GCDT). The qualitative instruments were the semi-structured interview questions on identifying student teachers misconceptions in genetics. Various descriptive and statistical analyses employed on the data collected. The results showed that the group, which underwent TEWA intervention, showed higher level of transformative experience and greater conceptual change than the comparison group. Implications for transformative experience as a conceptual change pedagogical technique discussed.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Mastering of science and technology has become a prominent task for Malaysia to achieve its vision as a developed nation status. This is because science and technology often considered as fundamental factors of economic development in industrialized countries (Othman Talib, Luan, Azhar & Nabilah Abdullah, 2009). The major role of science education in Malaysia is to encourage student's interest towards science and technology and to develop their creativity and innovation through experiences and inquiry (Kementerian Pelajaran Malaysia [KPM], 2011). Biology as one of the pure science subjects, occupies a vital position in the Malaysian school curriculum. According to Yusof and Afolabi (2010), Biology is basic to many science related courses such as medicine, pharmacy, agriculture etc. Therefore, any student who intended to master in this field must study Biology. Hence, these situations have drawn the attention of researchers and curriculum developers towards Biology as a crucial subject in the school curriculum.

According to Agorram, Zaki, Selmaoui, and Khzami (2017), students of the 21st century must have the scientific and technological knowledge and skills that will make them members capable of making responsible decisions in their daily and professional lives and play their role effectively in a world that is constantly changing, characterised by rapid production of knowledge. To this end, they must acquire a thorough knowledge and understanding of the basic scientific and technological concepts and simultaneously demonstrate problem-solving skills and critical thinking skills in all kinds of situations.

Millar (1989) stated that lacking of conceptual understanding on science would be a great obstacle for students to involve in scientific discussions or issues pertaining to science and technology. In line with this, Mashnad (2008) added that science instruction greatly depend on mastery of science concepts among students. Hence conceptual understanding is crucial to successful and meaningful teaching and learning. Therefore, Etobro and Banjoko (2017) pointed that science education and science teachers should take priority for the supplying of scientific literacy, which is required for making informed decision about genetic related controversial issues imposed by daily life.

According to Gabel (2003), understanding of science concepts is a challenging issue in teaching and learning science. Gabel stressed that, it involves learning and explaining the major properties of a phenomena and processes using models, symbols and furthermore it involves understanding of processes that scientists employed in inquiry. Gabel further argued that, for an instruction to be effective, science needs to be taught in an organized manner to ensure that one concept builds upon another. Hence, science educators should focus on exploring ways to improve students' understanding of science and subsequently help them to see its relevance in their daily life.

A study by Bartholomew, Moeed and Anderson (2011) stated that teacher confidence and knowledge has a great effect on classroom practice. Teacher confidence can determine the occurrence of science education in the classroom. Their study suggested that student teachers should be exposed to learning experiences that will enhance their practice and expertise in order to have a strong foundation to face their students' learning needs in future.

According to Paris (2000), in order to be effective science teachers, knowledge of science is crucial. This is essential for science teachers for meaningful teaching of biological concepts and encouraging their students' intellectual curiosity. Paris stated that, science educator George R.Twiss (1917) recognized the importance of adequate preparation for those who are to become science teachers**.** He was convinced that clear and comprehensive understanding of science is a fundamental requirement for teachers of science. Puk and Stibbards (2011) further argued that complicated conceptual understanding among prospective teachers is vital in their area of expertise. This is important because prospective teachers expected to facilitate their future students' understandings of science concepts. In line with this, Moe (2011) stated that an understanding on the role of science is fundamental to make sense of scientific knowledge, to determine the value of science to people, and how science can be applied in everyday life.

According to Pugh, Bergstrom, Heddy and Krob (2017), students are able to enhance and expand their daily life experience outside the classroom through science education. Unfortunately, the transformative potential of science education often goes unrealized even in the context of effective science teaching methods such as inquiry and conceptual change instruction (Heddy & Sinatra, 2013). In line with this, students often fail to apply school learning outside of class and use it to enrich their interactions with the world.

Pugh, Gercia, Koskey, Stewart, and Manzey (2009), stated that scientific understanding would be effective if students are able to apply it in everyday experience. Therefore, transformative experiences occur when students actively use learned concepts in daily life to see and experience the world in a new and meaningful way (Pugh, 2011). A transformative experience can be explained based on three major qualities namely active use of the concept, an expansion of perception, and experiential of value. The term active use here refers to the ability of an individual to use the concept learned as a potential lens to view the world, specifically out-of-school senario. Naturally, individuals perform transformative experiences when they frequently use a concept, able to see the world in a new way and could value the way of seeing things (Pugh & Girod, 2005).

In reference to science education, Dewey's findings suggested that science concepts can engage individuals in transformative experiences, if those individuals engage with the concepts as ideas (Pugh, 2002). As mentioned by Dewey (1933), concepts are established meanings, whereas ideas conditionally held meanings. In particular, they are possibilities that inspire anticipation, action, and emotion. Many of the seemingly mundane science concepts taught today were once powerful ideas. For instance, the view of the sun as the center of the solar system was once a powerful idea or a powerful possibility to the contemporaries of Copernicus. It instigated action in astronomers and theologians alike, and it transformed their perception and value, not only of the heavenly orbs but also of God's plan and man's place in the order of the universe (Pugh, 2002). However, in most science classrooms today, the power of this idea to inspire action and transform perception and value is largely lost. The idea has become a standardized concept learned and understood. Therefore, one of the key tasks of teaching for transformative experience is to reanimate concepts, transformed them into ideas.

Shulman (2002) stated, “learning begins with student engagement” (p. 37). Student-centered teaching methods are those that engage students in active learning. These strategies have been shown to promote and facilitate students’ understanding and application of scientific concepts (Badara, 2011; Lee & Jabot, 2011). Transformative experience reflects on students’ involvement or engagement in learning. According to Fredricks, Blumenfeld and Paris (2004), the intention of students involvement in learning is refers to engagement. In line with this, transformative experience is categorised as a form of engagement, which consists of three characteristics of transformative experience, namely active use of an idea, expansion of perception, and value development. Hence, transformative experience significantly expands and subsequently include engagement with content in daily life experience.

According to Pugh (2002), the students engagement with an idea is a very unique which makes it very different from ordinary experience. In other words, when students engage with brilliant ideas they experience many of the same qualities that obviously define an experience as an expansion of perception and value. Hence, in an experience, one sees the world through the involvement of oneself or others in a new way. Pugh categorised this as a way to find new meaning in this aspect of the world, and to value this new way of seeing. Based on the work of Dewey, Pugh (2002) has developed the construct of transformative experience and implemented it as tool to study students’ engagement in science. Fredricks et al.(2004) argued that engagement is an effective domain in education because it potentially can integrate various construct such as motivation and cognitive strategies which can result in an intergrated framework for studying. Moreover, engagement is also prominent in addressing conceptual learning in science.

In the current context of teaching and learning biology, transformative experience reflected at a minimal level (Badara, 2011). However, engagement as an important experience that students should possess in transformative experience potentially related with other important outcomes such as transfer. Hence this refers to contextual application of learning**,** conceptual change, and individual interest. These constructs involved special aspects, which are crucial to enrich and transform everyday experience. Researchers have insisted that fostering of conceptual change in students is necessary. This is due to that students tend to hold onto their existing conceptual understandings, which often hinders learning of new scientifically related conceptual frameworks (Tekkaya, 2002; Ekici, Ekici, & Aydin, 2007). Since transformative experiences involve a meaningful integration of science content into everyday experience, they are very effective in overcoming misconceptions (Pugh et al., 2009).

According to Mbajiorgu, Ezechi, and Idoko (2006), Science is a troublesome subject to comprehend and ace, where paying little respect to age, culture, and training foundation, many individuals convey their own comprehension of science. In accordance with this, genetics is not a special case in this issue. Research on student understanding of genetics concepts by Osman, BouJaoude and Hamdan (2017) has revealed that many middle and high school students harbor misconceptions that affect their ability to accurately describe genetically related life phenomena and explain complex genetics processes. Since genetics is an extremely wide and convoluted theme, it is thought to be a standout amongst the most troublesome ideas in Biology. The systems are difficult to comprehend in light of the fact that it is hard to influence the plans to be substantial without the assistance of uncommon instruments (Flodin, 2007).

According to Infante-Malachias, de Mello Padilha, Weller and Santos (2010), many authors have described students' misunderstandings regarding established concepts of genetics and diversity of people's ideas about inheritance (Lewis et al., 2000 a and b; Marbach-Ad & Stavy, 2000; Saka, Cerrah, Akdeniz and Ayas, 2006; Duncan & Reiser, 2007). Therefore, it is important to understand if basic genetic knowledge, such as the laws of Mendel, which transmitted to students before reaching the university, well understood. Furthermore, it is also vital to know what happens with this understanding throughout the years of college, a time in which acquisition of scientific concepts recognised as fundamental to learners, especially among future Biology teachers.

A study by Dikmenli (2010) concluded that student teachers possess inadequate knowledge and numerous misconceptions in biology particularly identified with the physical connections between the genetic material and the chromosomes, and the connections between the behavior of the chromosomes and progression of genetic information. Analysis of the drawings in Dikmenli's study uncovered that applied comprehension of these biology student teachers is generally frail especially with respect to the behavior of the chromosomes, chromosome numbers, alterations occurring at the organelles, phases of the cell division, and the DNA replication during mitosis and meiosis.

A study by Etobro and Banjoko (2017) revealed that 75.1% on the average of student teachers had misconceptions about genetics concepts. This percentage of student teachers who have misconceptions could have been due to wrong understanding of the teachers to the concepts of genetics. Their findings further showed that over 80% on the average of student teachers attributed the misconceptions about genetics to challenges in genetics textbooks, instructional methods in teaching genetics, student teachers' cultural beliefs and practices and abstractness of genetics. Therefore, educators at the primary and secondary school levels, and instructors at the higher learning organizations should assume an imperative part in planning and implementing alternative instructing systems to dispose of or possibly limit such misconceptions. Effective teachings techniques must be utilised to eliminate or limit these misconceptions among student teachers. Otherwise, the new teachers will keep educating these misconceptions and the cycle would not be broken (Dikmenli, 2010).

Researchers have identified numerous strategies to overcome misconceptions, namely the Learning Cycle approach (Turkmen & Usta, 2007); concept maps (Sungur, 2000; Yilmaz, Tekkaya & Sungur, 2011), conceptual change texts (Novak & Canas, 2004; Tekkaya, 2003), analogies (Duit, 1991; Glynn, 2007, Harrison & Treagust, 1993; Guerra-Ramos, 2011) and Teaching with Analogies (TWA) model (Glynn, 1991). As of late, the significance of models in science instruction has been perceived with an expanding measure of research consideration

(Greca & Moreira, 2000; Glynn, 2007; Guerra-Ramos, 2011). Research evidence shows that models, representations and analogies are now generally utilised as metacognitive instruments in science instructions (Duit, 1991; Greca & Moreira, 2000; Harrison & Treagust, 1996). Coll (2005) argued that research findings showed that the utilization of analogies and models within the science teaching method could improve understanding on nature of science and science endeavor. In addition, latest researches findings have demonstrated that some pedagogical methods to deal with analogical model utilize have empowered students to create and improve their comprehension of logical ideas (DeGroot, 2009; Morsanyi & Holyoak, 2010; Guerra-Ramos, 2011).

1.2 Background

Malaysia as a country that is advancing towards developed nation status, needs to make a general public that is scientifically oriented, dynamic, learned and having a high limit with regards to change. Besides the public additionally ought to be forward-looking, inventive and a supporter of scientific and technological developments in the future. In accordance with this, there is a need to create citizens who are inventive, critical, curious, liberal and capable in science and innovation (Curriculum Development Center [CDC], 2006). The Malaysian science educational programmes involve three major science subjects and four elective science subjects. The core subjects are Science at primary school level, Science at lower secondary level and Science at upper secondary level. Elective science subjects are offered at the upper secondary level and comprise of Biology, Chemistry, Physics, and Additional Science. As all the major sciences, Biology curriculum aims at providing students the information and aptitudes in science and innovation and empowers them to tackle issues and make decisions in regular day-to-day existence in view of logical states of mind and honorable esteems. Students who have followed the biology curriculum will have the establishment in science to empower them to seek after formal and informal further training in science and innovation (CDC, 2006).

According to Kubiatko and Prokop (2007), Biology education ought to furnish teachers with information and abilities that assistance them to comprehend regular day-to-day existence in nature. The significance of biology education lately increases due to the solid effect of present day innovations. Based on a study by Pugh (2002), the popular notion that science education ought to improve students' regular experience was translated to mean the science education should bring about transformative experiences. In other words, the learning of science concepts should allow students to act on the world in new ways, to more fully perceive or understand the world, and to expand the meaning and value they attach to the world. Therefore, transformative experience is an esteemed learning result in its own right (Vosniadou & Brewer, 1992). This research will feature the predominance of transformative experiences in genetics in terms of three interrelated and associated qualities: motivated use; expansion of perception; and experiential value, which concentrate on Genetics as the subject matter. Besides, this investigation additionally plans to inspect the viability of transformative experiences in overcoming misconceptions regarding genetics among student teachers. The transformative model fits inside a constructivist worldview where people build information through their encounters on the planet (Moore, 2005).

According to Pugh (2004), transformative experiences have been characterised as those experiences in which students effectively utilize science ideas to see and experience their regular world in important, new ways. Moreover, in light of the fact that transformative experiences include a significant combination of science content into ordinary experience, they are likely valuable to effectively overcoming misconceptions and for encouraging exchange among theoretical thoughts. Unfortunately, little is thought about how much science education encourages transformative experiences and only a few empirical researches has analyzed potential variables prompting engagement in transformative experiences (Pugh, 2004). A study by Pugh (2002), found that secondary school biology students who experienced transformative experiences accomplished measurably huge gains in persisting applied understanding compared to students who did not undergo transformative experiences. Furthermore the analysis of conceptual understanding in a research by Girod, Twyman and Wojcikiewicz (2010), gives imperative information recommending students instructed for transformative experience, learn more than those educated from a psychological and rational structure. Despite the fact that these distinctions were genuinely little they were measurably huge.

Transformative learning depicts the learning procedure that prompts point of view change in adulthood. As Mezirow (1997a) states, basic reflection and considering presumptions is crucial to changing the student's casing of reference to accomplish instructive objectives. Science instructors have indispensable part in science education since they will teach the more youthful age. In any case, students' comprehension of a few biological topics regularly varies from those of scientists. Tekkaya (2002) stated that, a significant group of research has concentrated on students' understandings of scientific phenomena; particularly studies concerning students' comprehension of natural ideas demonstrate that students of different ages have misconceptions about science ideas.

According to Duit and Treagust (2003), research data gathered over three decades has demonstrated that the greater part of students come to science classes with pre-instructional learning or convictions about the phenomena and ideas to be educated. Numerous students grow just a restricted comprehension of science ideas following direction. These students build sensible and coherent understandings of phenomena and ideas as observed through their own eyes. However, their understandings do not coordinate the perspectives that universally acknowledged by established researchers. The misconceptions or alternative conceptions, if not tested, end up plainly coordinated into students' subjective structures and distract the consequent learning (Kose, 2008; Treagust, 2003).

According to Cakir (2011), genetics is one of the areas of biology in which learners have difficulties. Particularly, the conceptual area of genetics investigates biological patterns of inheritance and variation. A survey of high school teachers indicated that Mendelian genetics, meiosis and mitosis, and the chromosome theory of inheritance were regarded among the most difficult, yet the most important topics of study for higher learning students (Johnson & Stewart, 2002). The presence of these misinterpretations, regardless of the reality understudies are instructed with different training methods at the institutes of higher learning, demonstrate that such misconceptions are to a great degree impervious to change (Bahar, 2003;

Wandersee, 1983; Yesilyurt & Kara, 2007; Williams, 2009; Leppavirta, 2011; Sharifah Norhaidah Idros,1999).

According to Osman, BouJaoude and Hamdan (2017), a study carried out in schools in Lebanon, revealed that their educators claim that middle and secondary school students exhibit poor understanding of science concepts, particularly genetics due to misconceptions and difficulties that hinder progression in conceptual understanding of major genetics concepts and phenomena across different grade levels. They attributed these problems to Lebanon's ill-structured genetics curriculum, which needs a thorough revision in light of curricular reform models that take into account student misconceptions, cognitive abilities, and past experiences.

Instructors agreed that prevalence of misconceptions among students not just displays a genuine obstruction to learning in biology yet additionally distract with further learning (Dikmenli, 2009; Bahar, 2003; Wandersee, Mintzes & Novak, 1994). According to Sharifah (1999), the fundamental obstruction to most students in gaining right ideas in genetics has an awesome arrangement to do with the way that the majority of genetics ideas are hypothetical ideas, which are theoretical, and not elucidating ones. The concept of 'gene' is itself a hypothetical idea and should be comprehended as far as different ideas, for example, heredity, the mix of qualities expected to realize a specific phenotype and in addition the hypothesis that clarifies phenotype and genotype (Sharifah, 1999). In this manner to advance powerful and important learning, there is a need to recognize the reasons for such misconceptions and discover approaches to amend them or keep them from happening.

As an outcome, students will encounter trouble in coordinating any new information inside their subjective structures, bringing about an unseemly comprehension of the new idea. These misconceptions would remain in students who are pursuing their studies to become teachers. Various researches revealed that numerous biology instructors including those with experience and pre-service teachers show misunderstandings of various biological concepts, particularly genetics that includes biological patterns of inheritance and variation, Mendelian genetics, meiosis and mitosis, and the chromosome (Yip, 1998; Barrass, 1994; Sanders, 1993; Puk and Stibbards, 2011; Cakir, 2011; Hoewyk, 2012). Eventually, such wrong ideas would be passed on to their students through incorrect educating.

According to Yilmaz et al. (2011), when the students unable to build compelling linkages between their current information and the new learning, development of right conceptions is forestalled, which thusly prompts rote learning (Novak & Canas, 2004; Effandi & Zanaton, 2007). In rote learning, students do not coordinate new ideas to their earlier information to shape a reasonable framework. Therefore, they have a tendency to depend on remembering disengaged certainties (Novak & Canas, 2004). Specialists assert that students who much of the time utilize rote learning have a tendency to produce misconceptions concerning scientific ideas (Dogru & Tekkaya, 2008; Yilmaz et al., 2011). Genetics is among such topic that students have a tendency to learn through repetition (Cavallo, 1996; Yilmaz et al., 2011). A few specialists have additionally demonstrated that genetics is a standout amongst the most imperative and troublesome subjects of science to learn (Kindfield, 1991; Law & Lee, 2004; Smith & Williams, 2007; Venville & Donovan, 2007). Major ideas of genetics that the students do not completely comprehend include chromosomes, qualities alleles, homozygous, heterozygous, dominance, recessiveness, mitosis, meiosis, and fertilization (Lewis, Leach, & Wood-Robinson, 2000a, 2000b; Slack & Stewart, 1990; Dikmenli, 2010; Cakir, 2011). Students with these limited understandings would leave secondary education and proceed to tertiary education where they will face difficulty in pursuing biological courses effectively. Furthermore, students with the intention to do science-teaching courses will face obstacles in understanding of key biological concepts, particularly in genetics.

Regarding limited or wrong understanding of the teachers pertaining genetics concepts, the findings of Etobro and Banjoko (2017) study, revealed that 75.1% on the average, of student teachers had misconceptions about genetics concepts. This percentage of student teachers who have misconceptions could have been due to wrong understanding of the teachers to the concepts of genetics. This finding is in agreement with Mustami (2016) who attributed this wrong understanding to the incompleteness of information students received from their learning experiences and from their peers. This naive experience of the student teachers could have influenced the misconceptions that were observed in genetics concepts.

Research by Deshmukh and Deshmukh (2001) uncovers that text books, reference books, educators, dialect, social convictions and practices are a portion of the main sources of secondary school students' misconceptions of numerous science ideas including concepts in Biology. The findings of the investigation demonstrate that there is an earnest requirement for look into based material to overcome students' misconceptions. One reason for students to have misconceptions is the confusions that instructors have (Kose, 2008). Therefore, student teachers need to be educated in an appropriate way, so that these teachers would be able to impart the right knowledge to their students when they become teachers. Student teachers must be prepared with effective teaching techniques, which will have the capacity to address the misconceptions, or regular convictions they have about the ideas. This would be a feasible way to deal with amend the misconceptions of the educators and as well as the students sooner rather than later.

According to Erdagon, Ozel, Boujaoude, Lamanauskas, Usak, and Prokop (2012), there have been few studies in the past two decades examining the knowledge of pre-service teachers toward biological concepts specifically biotechnology. For example, Prokop, Le ková, Kubiatko and Diran (2007), investigated pre-service students' knowledge in Slovakia toward biotechnology. The findings of this research showed that students have poor knowledge about biotechnology specifically concepts related to genetic engineering. Turkmen and Darcin (2007) examined the levels of knowledge of Turkish elementary and science student teachers in biotechnology issues. Their results showed that despite the fact that prospective teachers were knowledgeable about biotechnology and its relation to human health and pharmacy, almost all of them had inadequate knowledge about agricultural biotechnology, environmental biotechnology, and food production.

According to Yilmaz et al. (2011), students faced difficulties in understanding various genetics application fields due to fragmented comprehension of genetic ideas which lie under the ontological contrasts. The ontological contrasts are seen between the levels of genetics phenomena (Duncan & Reiser, 2007), theoretical nature of ideas (Law and Lee, 2004), and relatedness of these ideas to various levels of associations, specifically, plainly visible level (organismal), microscopic level (cellular) and submicroscopic level (biochemical), which require association among each other for coherent comprehension (Marbach-Ad & Stavy, 2000). Yilmaz et al. (2011) added that students ought to interface every genetic idea with each other to understand further scientific ideas for example, reproduction, biodiversity, mutation, adaptation, evolution and day by day life uses of genetics, for example, cloning, medicine, agribusiness, forensic science, and genomics. In addition, keeping in mind the end goal to be successful science educators later on, student teachers ought to have a careful comprehension of essential ideas of genetics. Along these lines, significant learning of genetic ideas has turned into an imperative issue. Specialists have offered alternative techniques to advance significant learning in science and to confront the alternative conceptions in genetics (Law & Lee, 2004).

Traditional science teaching method is an obstructing factor on students' mastering of science concepts (Azizah & Shaharom, 1999; Effandi & Zanaton, 2007;Karagoz & Cakir, 2011). They argue that this teaching method is teacher centered, emphasizes merely on memorizing of facts and is examination oriented. Effandi and Zanaton (2007) further argued that, this lecture-based instruction emphasized the passive way of gaining knowledge. In such a situations, students become passive learners and fall back to rote learning. Hence, students are simply poured with many facts and various science concepts while the students' understandings of concepts are ignored. Consequently, students leave the secondary school system with various misconceptions in science (Johari Surif, Nor Hasniza

Ibrahim & Mohammad Yusof Arashad, 2007). Eventually the science student teachers' training programme, which intakes based on these secondary school leavers, would have trainees with various biological misconceptions.

The conventional technique utilised in most science classes does not provide students enough time for sound understanding (Kose, 2007). DeGroot (2009) expressed that the utilization of simile, analogy, and metaphor in educational environments has long been used to help learners make connections between complex scientific concepts and concepts that are familiar in everyday life. Duit (1991) argues that the previllages of analogies take after from the way that they open new viewpoints; they may give representation and encourage comprehension of the conceptual by pointing out similarities; they may incite students' advantage and persuade them; and they urge the educator to think about students' underlying thoughts and hence this may uncover misconceptions.

Learners use prior knowledge to assimilate and eventually accommodate new knowledge which enabling them to develop better understanding of science concept. According to DeGroot (2009), analogies allow assimilation of prior knowledge to accommodate with new ideas for effective understanding of science concepts. Glynn (1991), Harrison and Treagust (1993), Thiele and Treagust (1995), Yanowitz (2001) and Centigul and Gebon (2011) developed strong arguments for analogy as an effective tool for conceptual understanding in science. One very important tool that has emerged from analogy research is the Teaching with Analogy (TWA) Model. It is a constructivist approach developed by Shawn Glynn and colleagues (Glynn, 1991). TWA was developed through the analysis of physics and physical science textbooks. Harrison and Treagust (1993) applied TWA in the teaching of optics to high school sophomores in Australia. One of the major results of the study is that TWA provides an effective framework for educators to integrate analogies into classroom instruction (DeGroot, 2009). In both formal investigations and classroom settings, the utilization of the model has been found to expand students' learning and understanding of science ideas (Glynn, Duit, & Thiele, 1995; Paris and Glynn, 2004). Pugh (2011) stated that when students effectively utilize curricular ideas in regular day-to-day existence, they will see and experience the world in new useful way. This is when transformative experiences happen. With reference to the focus of the study, the transformative teaching and learning experience is incorporated with Teaching with Analogy (TWA) Model (Glynn, 2004, 2007) to produce an adapted Transformative Experience with Analogy (TEWA) module, which was used to deliver the content of Genetics.

In this manner, teacher education programs, which are not prone to have the capacity to influence students to develop correct conceptions, need to measure the long term effects of having student science instructors' graduate before they find the opportunity to investigate and endeavor to change their misconceptions about scientific thoughts (Akgun, 2009). Therefore, the focus of this research is on how science student teachers' misconceptions could be corrected and strengthened their biological conceptual understandings through engagement in transformative experiences.

1.3 Problem Statement

Many have argued that science education should not only ensure conceptual understanding but also should enrich students' everyday experience (Pugh, 2002). In general, the various perspectives on science education have focused more on how engagement in enriching experience fosters conceptual development change but rather less on how engagement with concepts fosters enriched experiences. Unfortunately, the transformative potential of science education often goes unrealised, that is, students often fail to apply school learning outside of class and use it to enrich their interactions with the world. This outcome is unfortunate as prominent educators, such as Dewey (as cited in Pugh et al., 2017), have argued that enriching and expanding experience should be a central goal of education. As connected to science training, Dewey's work proposes that science ideas can involve people in transformative experiences, if those people involve with the ideas as thoughts (Girod, 2000). Evidence that science concepts can foster transformative experiences comes from the personal accounts of scientists (Pugh, 2002). For example, Dawkins (1998) comments,

> "I can think of very few science books I've read that I've called useful. What they've been is wonderful. They've actually made me feel that the world around me is a much fuller, much more wonderful, much more awesome place than I ever realized it was" (p. 37)

For Dawkins, it was not art but the concepts found in science books that allowed him to see the world in a wonderful, new way.

Pugh et.al, (2009) argued that, from the Deweyan perspective, the acquisition of conceptual understanding and legitimate participation in a science discourse community are valuable outcomes but not sufficient for a complete learning experience. For a learning experience to be complete, it must yield an expanded experiencing of the everyday world. It must be transformative. Transformative experiences have been defined as those experiences in which students actively use science concepts to see and experience their everyday world in meaningful, new ways (Pugh, 2004). In addition, since transformative experiences involve a meaningful integration of science content into everyday experience, they are likely beneficial to successfully overcoming misconceptions. Transformative learning is a long-standing tradition in education, yet there is little empirical research investigating the potential benefits of transformative experience for learning in science (Pugh et al., 2009). A likely reason is the difficulty of studying a construct such as transformative experience. It is only recently that the field of education has begun examining complex, holistic constructs in a scientifically sophisticated way. As a result, we know little about the nature of transformative experiences and the role they may play in learning. This study, tend to address this gap by studying the prevalence of transformative experiences during science learning, particularly genetics and consequences of transformative experience on conceptual understandings.

Researches on students' comprehension of biology concepts demonstrate that numerous students have misconceptions of numerous ideas that are essential to an intensive information of biology (Soyibo, 1993). Among the ideas researched are the circulatory system (Arnaudin & Mintzes, 1985), dissemination (Westbrook and

Marek, 1991), ecological ideas (Adeniyi, 1985), osmosis (Friedler, Amir & Tamir, 1987), photosynthesis (Wandersee, 1983), photosynthesis and respiration (Soyibo, 1983), & in addition students' misconceptions about hereditary genetics (Lewis, Leach & Wood-Robinson, 2000a; Duncan & Reiser, 2007; Kibuka-Sebitosi, 2007; Cakir, 2011; Etobro & Banjoko, 2017.

A study by Cakir (2011) on prospective secondary science teachers revealed that most biology major student teachers did not hold a strong conceptual understanding of Mendelian genetics. According to Cakir (2011), at the beginning of his study most participants demonstrated a very mechanistic understanding of gamete combination and probability. In spite of their extensive coursework in biological sciences, they did not have firm conceptual understandings of Mendelian genetics. Almost all the prospective teachers knew how to construct and use a Punnet square for solving genetics problems; yet, the conceptual knowledge and cognitive operations behind the Punnet square were mostly absent. Besides this, Cakir (2011) also encountered another problem among these student teachers which they frequently used the concepts of allele and gene, interchangeably.

Studies in the Malaysian context also reveal the existence of misconceptions among student and in service teachers. Research by Tan and Chin (2002), on forty-four student teachers who underwent 14 week science training in one of the Malaysian Teachers' Training Institute reveals that 56.82% of the respondents have misconceptions. Their findings showed that the most obvious misconceptions among these science teachers are on basic science concepts such as gravitational force and photosynthesis and on science process skills, particularly on making hypothesis. An investigation by Sharifah (1999) revealed that 38.19% (N= 560) of students studying a matriculation programme at University Science Malaysia referred to genetics as the most troublesome part of biology. Advance examination on their logical thinking performance showed that only 16.67% of them were working at the speculative deductive level expected to effectively comprehend genetics ideas, which are viewed as theoretical.

Therefore, teacher educators should play a vital role in applying alternative instructing techniques to wipe out or if nothing else limit such misconceptions (Tekkaya, 2002). Compelling teaching strategies must be utilised to eliminate or limit these misconceptions among secondary school students (Dikmenli, 2010). Bahar (2003) suggested that there are a few procedures and methods that can be utilised for externalizing thoughts and altering misconceptions in students' cognitive structure. These procedures called as conceptual change methodologies. Some of these are word association tests, basic correspondence framework, clinical interview, interviews about instances and events, prediction-observation and explanation (White & Gunstone, 1992), concept maps (Bahar, 2003; Sungur, 2000), related diagrammatic, classroom discussions, computer simulations (Williams, 2009; Cakir, 2011), diagnostic tree, journal writing, conceptual change texts, discussion web, and analogy (Glynn, 1991; Guerra-Ramos, 2011).

Stavy's (1991) study proposed that analogy could be a helpful procedure in conceptual change, countering a misconception of distinction between phenomena that are indistinguishable. According to Cetingul and Geban (2011), analogies make new ideas understandable to students by contrasting it with the idea that is as of now recognizable to them. Students discover topics more intriguing when they have some pertinence with their everyday lives and experiences. Numerous tests have been conducted to test the impact of analogies in learning complex scientific contents and encouraging conceptual change. Nottis (1995) added that analogies can facilitate the learning of difficult-to-comprehend concepts and encourage deeper cognitive processing. A study by Faikhamta (2012) reflected the educators' comprehension of which ideas of Nature of Science (NOS) are to be instructed, would decide the determination of fitting instructional materials, and the utilization of pedagogical tools such as metaphor and analogy to enable students to understand NOS well.

Glynn (2007) stated that analogies can enable students to assemble conceptual bridges between what is recognizable and what is new. Frequently, new ideas speak to mind boggling, hard-to-visualize frameworks with collaborating parts (e.g., a cell, an ecosystem, photosynthesis). Analogies can act as early mental models that students can use to frame limited yet significant understandings. Analogies can assume an imperative part in helping students build their ideas and consistent with a constructivist perspective of learning. According to Coll (2005), analogies may be considered a subset of models as they involve the comparison between two things that are similar in some respects. They are often used by scientists to explain abstract science concepts as well as when they are developing the complexity of their mental models. As students develop cognitively and learn more science, they will evolve beyond these simple analogies, adopting more sophisticated and powerful mental models.