DEVELOPMENT OF PROZYME BOARD GAME FOR TEACHING AND LEARNING ENZYME TOPIC IN BIOLOGY FORM 4

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ABSTRACT

This study aimed to develop a valid and reliable educational board game for teaching and learning enzyme topic in Biology Form 4. Prozyme board game was developed in accordance to the national curriculum standard for Biology Form 4. This study adopted quantitative research design. Students' experience after using Prozyme board game was measured through survey. The data were presented as descriptive statistics. The developed Prozyme board game was validated by five experts. The study findings showed that the assessment on the validity of Prozyme board game had high percentages of agreement values. In addition, high reliability value was also recorded. The findings from the study suggested positive views on students' learning experience using Prozyme board game. Furthermore, mean score values obtained from the pilot study were at high levels for all of the measured constructs. In conclusion, the use of Prozyme board game has added to the variability of instructional tools in teaching and learning enzyme topic. Prozyme board game has emphasized experiential learning in Biology. As an implication, Prozyme board game can be considered as a suitable teaching aid tool to be used in teaching and learning enzyme topic in Biology Form 4.

PEMBINAAN PERMAINAN PAPAN PROZYME UNTUK PENGAJARAN DAN PEMBELAJARAN TOPIK ENZIM BIOLOGI TINGKATAN 4

ABSTRAK

Kajian ini bertujuan membina permainan papan pendidikan yang sah dan mempunyai kebolehpercayaan untuk pengajaran dan pembelajaran topik enzim Biologi Tingkatan 4. Permainan papan Prozyme telah dibina mengikut standard kurikulum kebangsaan Biologi Tingkatan 4. Kajian ini menggunakan reka bentuk kuantitatif. Pengalaman pelajar setelah menggunakan permainan papan Prozyme diukur menggunakan soal selidik. Data dipersembahkan dalam bentuk statistik deskriptif. Permainan papan Prozyme yang dibina telah disahkan oleh lima orang pakar. Dapatan kajian menunjukkan bahawa penilaian terhadap kesahan permainan papan Prozyme mempunyai nilai peratus persetujuan yang tinggi. Tambahan, nilai kebolehpercayaan yang tinggi telah direkodkan. Dapatan kajian mencadangkan pandangan yang positif terhadap pengalaman pembelajaran pelajar dengan menggunakan permainan papan Prozyme. Begitu juga, nilai min daripada kajian rintis berada pada tahap yang tinggi bagi keseluruhan konstruk yang diukur. Kesimpulannya, penggunaan permainan papan Prozyme telah menambahkan kepelbagaian alat instruksional dalam pengajaran dan pembelajaran topik enzim. Permainan papan Prozyme menekankan pembelajaran berasaskan pengalaman dalam pembelajaran Biologi. Implikasinya, permainan papan Prozyme boleh digunakan sebagai alat bantu mengajar yang sesuai di dalam pengajaran dan pembelajaran topik enzim Biologi Tingkatan 4.

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ESICI	Enzyme Substrate Interaction Concept Inventory
MoE	Ministry of Education
SMK Kerambit	Sekolah Menengah Kebangsaan Kerambit
SPSS	Statistical Packages for Social Science
ZPD	Zone of proximal development

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CHAPTER I

INTRODUCTION

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This chapter discusses the overview of science education in Malaysia, research background, theoretical framework, problem statement, research objectives, research significance and its limitation.

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1.1 Overview of Science education in Malaysia

Malaysia is one of the developing countries with continuous improvement in many sectors, including education. The importance of education in Malaysia had increased over time, and many transformations have been introduced to ensure good coverage of high-quality education for Malaysian. National Education Policy has been introduced as a guideline or reference to produce individuals that are knowledgeable, innovative and critical on what are being taught in our educational institutions (Ministry of Education, 2005).

Science is known as the most needed knowledge components in education. According to The National Science Education Standard, science is an area for every student and involve active processes (National Research Council, 1996). Science in primary and secondary school include physic, chemistry, and biology. Learning science encourage students to act like a scientist. Observation and collection of information are required so that students can make their idea along with high appreciation and a high level of understanding. Due to this, science curriculum is one of the most important education component in Malaysia. Learning science in school will provide a foundation for students to pursue their studies in this area.

Biology is one of the dimension that has continuous growth. Learning biology requires students to experiment with living things in laboratory or fields (Prokop, Prokop, & Tunnicliffe, 2007). As suggested by Prokop et al. (2007), biology is one of the science subjects that receive small number of student enrollment. This is probably due to the fact that most male students find it difficult to learn biology.

Learning biology that seems complicated for the students has lead to low interest in learning (Bramwell-Lalor and Rainford, 2014). Therefore, ministry, school administration and teachers should work and find ways to attract students to choose science Biology path in school.

1.2 Research background

Integrated Curriculum for Secondary School (Kurikulum Bersepadu Sekolah Menengah/ KBSM) had introduced many interesting topic such as cell structure, the chemical composition of the cell, cell division, and respiration in Biology subject. These topics are related to each other and served as prior knowledge for students to further their studies in tertiary education. Even so, adequate understanding of these topics is substantially challenging for students. Teaching and learning strategies must be suitable or unique to these topics. Ministry of Education (2005) had introduced inquiry, constructivism, contextual learning and mastery learning strategies.

All in all, teacher need to improve their knowledge and skill for them to better equip their students better in the future (Halim and Meerah, 2006). Bone and Reid (2011) stated that students who excel in the secondary level of education does not expect to do well in their university time due to lack of basic knowledge. Moreover, Bretz and Linenberger (2012) stated that students will bring what they had learned in secondary school to the university.

The enzyme is one of the topics included in the chemical composition of the cell (Chapter 4) in Form Four Biology. In this topic, students should be able to define enzyme, their characteristics, factors affecting enzyme and daily use of enzymes (Ministry of Education, 2005). Even though this topic does not as much of the concern if compared to cell division, diffusion or genetic, many pieces of research had identified various students' misconception on enzyme topic at higher education level.

Enzyme-Substrate Interactions Concept Inventory (ESICI) had been developed to measure students' understanding and misconceptions on enzyme topic. Interviews with students with representations such as a lock and key model becomes a base to develop the item in ESICI. In general, 15 items were used to measure students misconceptions on the enzyme in ESICI (Bretz & Linenberger, 2012). Based on ESICI, students are fond of developing misconceptions on enzyme-substrate interaction, how enzyme interact with substrate and characteristic of enzyme and substrate (Bretz & Linenberger, 2012). To sum up, although enzyme characteristic and interaction had been taught in secondary school, ESICI had found that most students still have misconception regarding enzyme-substrate interactions.

A further research had been conducted by Linenberger and Bretz (2014) to evaluate knowledge on shape and charge of enzyme-substrate interactions among university students. Their research involved interview and distribution of ESICI inventory for assessing students' level of understanding of enzyme-substrate interactions. During the interview, most students responded that enzyme and substrate are like a puzzle pieces.

Responses from ESICI implies that the student remain misunderstood on the concept of enzyme-substrate interactions. As for secondary school students, limited research had been done to identify misconception on enzyme topic. As described earlier, even university students still have a misconception on enzyme topic. Due to this, students need to understand the basic concept in secondary level thoroughly to avoid any misconceptions when they further their studies to tertiary level. Therefore, a right teaching and learning strategies provided by teacher is necessary to prevent misconception on the enzyme topic in secondary level.

Experiential learning is one of the theory that consider experience as a form of learning (Bergsteiner, Avery, & Neumann, 2010; Kolb, 2015). Experience includes interaction to environment. For students, experiential learning can be refer as students participation in activities designed by the teacher. In addition, costructivist learning is another theory that can be integrated in learning. This theory was introduced in Piaget's stages of development (Pritchard, 2005). Constructivist learning is defined as students constructed their new ideas and added to their prior knowledge, understanding and skills (Pritchard, 2005; Sreedevi, 2011). Several example of constructive learning approach includes peer tutoring, simulation, brainstorming, and cooperative learning (Sreedevi, 2011). Therefore, teachers need to modify their teaching strategies to involve more active learning among students and between student with teacher.

In addition to experiential learning strategies, inquiry instructional strategies can prepare students to learn science content and skills (Sadeh & Zion, 2011). According to Ministry of Education (2005), inquiry refers to learning through experiences such as activity or experiments, draw a conclusion and develop scientific skills with a guide from the teacher. Gado (2005) stated that inquiry instructional strategies can be used if equipments are adequate to develop students' scientific skills. However, teachers might have difficulties in conducting inquiry instructional strategies due to time and handling constraints (Gado, 2005). In conclusion, constructivism and inquiry instructional strategies are capable of preparing students to excel in science through active involvement.

Nowadays, many researches had been carried out and employed different active teaching methods especially in biology to deliver the content and to effectively develop students' scientific skill. The active teaching methods include simulation, experiments, outdoor activities, games, hands-on activities and concept mapping. These method engaged students in activities and improved their motivation and attitude towards science. These are highly different to traditional teaching method such as chalk and talk or lecture.

Learning can be fun and enjoyable for students to experience. Teachers must find ways to attract and gain students interest in learning biology (Holstermann, Grube, & Bögeholz, 2009). Educational game is one of the engaging methods of teaching and learning biology. Rieber and Noah (2008) explained that games involved experience and understanding to know the world.

Students who tend to use game in learning may experience experiential and authentic learning (Liu, Rosenblum, Horton, & Kang, 2014). Along with the advancement of technology, games and education have become popular in the classroom. Annetta, Cheng, and Holmes, (2010); Annetta, (2008); Mifsud, Vella, and Camilleri (2013) had described that game can be a suitable teaching strategies in the classroom.

1.3 Problem statement

Biology is a subject that had been introduced to secondary school and have promising future (Khan & Masood, 2014). Also, it had known as a hard subject and only abstract concept were generally taught in the school (Brown & Schwartz, 2009). Difficulties in learning Biology among students was influenced by the abstract concept (Khan & Masood, 2014). Bramwell-Lalor and Rainford (2014) had previously stated that students in secondary school unwillingly to take science path as they assumed that science is difficult with many sciences concepts to understand. An ineffective teaching techniques and poor assessment had become a factor that students are unable to explain the science concept better and led to lower order thinking. Therefore, to avoid any misconceptions on science concept, interactive and right teaching techniques become the priority among teachers (Bramwell-Lalor & Rainford, 2014).

Enzyme topic is one of the subtopics in chemical composition of the cell (Chapter 4) for Form Four Biology students in Malaysia secondary school. The main learning outcomes of this topic are students can define what an enzyme is, state the characteristic and its function in the cell and our daily life. Enzyme refers to a protein that act as a catalyst in the cell. As enzymes are important in the cell and our daily life, understanding the enzymes concepts is a must for students to avoid any misconceptions.

Several researchers had previously identified misconceptions on enzyme among students. Recently, Bretz and Linenberger (2012) had developed an inventory on enzyme-substrate interaction concept to find out any misconceptions on the enzyme. They found that students develop misconceptions about characteristics of the enzyme and enzyme-substrate interaction. The continuous studies were also done by Linenberger & Bretz (2014) also reported that students still have misconceptions on the enzyme-substrate interaction. Research done by Yip (1998) also stated that students always have misconceptions on optimum temperature for enzyme activity. Therefore, teaching and learning technique is the main point to look at to reduce misconceptions on the enzyme topic.

Lecture and experiment are widey use as the current strategy for teaching enzyme topic. In fact, active learning strategy such as games could serve as a tool for students to better understand some important concepts in enzyme topic. There are many pieces of evidence on the advantage using games in teaching and learning. However, little research had been carried out on the use of games for learning enzyme in secondary school, especially in Malaysia.

Therefore, the limited knowledge on the use of games in learning enzyme concepts had lead to the idea to conduct this study. In order to change the norm on teaching enzyme, game kit development has become a necessary effort. Thus, games kit named as Prozyme will be developed and used as a learning tool to teach students on enzyme concept in Biology Form 4 in this study. Evaluation of students' experience will be used to indicate if games kit is a suitable and usable for teaching enzyme topic.

1.4 Theoretical framework

Teaching and learning process that involved students' participation can be described as a type of active learning. Lewis & Williams (1994) defines active learning as other than listening, and students' doing more in the classroom. Active learning is also known as experiential learning (Lewis & Williams, 1994). Experiential learning form includes games, simulation, or role plays in the classroom. Students are able to transfer the knowledge from the classroom into their understanding by involving in activities (Taylor, Ka, & Chan, 2012). Active and practical experiential learning help students to gain deep understanding other than traditional classroom due to passive learning (Taylor et al., 2012). Through experiential learning, students develop deep learning experiences and affect on students' learning (Taylor et al., 2012).

Dewey (1938) in Taylor et al. (2012) stated experiential learning is uninterrupted and crucial in education. This had been supported by Piaget that learning is an ongoing process of finding knowledge, assimilation, and accommodation from experience (Koch, 2013).

Kolb's learning modes involve concrete experience, abstract conceptualization, reflective observation, and active experimentation (Sato, A., de Haan, J., 2016; Taylor et al., 2012). The learning modes emphasized a cyclic process on experience, reflect, think, and act to learning condition and what is being learnt (Taylor et al., 2012). Through this learning modes, students are encouraged to participate in activities, reflect on what had been learnt, think and efficiently develop knowledge. Therefore, learning activities suggested or developed by teacher need to consider on this four learning modes.

As discussed earlier, a deep understanding of subject matter depends on students' experience in activities. Game-based learning is one example of experiential learning. Educational games need to achieve its learning objectives and must be enjoyable for students (Gunter, Kenny, & Vick, 2006). According to Gunter et al. (2006), an educational game accentuated based on learning theory or educational study that tends to improve students' motivation and achievement. Gagne's Events of Instruction and Keller's ARCS Motivational Model were the two theories in game design principles (Gunter et al., 2006).

Gagne's nine events of instruction lead students' to dominate content and learning objectives. Gagne's highlighted that learning need to be mastered from low level to a high level (Gunter, Kenny, & Vick, 2008). Gagne's nine events of instruction comprised gain the students attention, inform the students of the objectives, stimulate recall of prior learning, present stimulus or lesson, provide instruction, extract performance, offer feedback, evaluate performance, and raise retention and transfer (Gunter et al., 2006).

Meanwhile, Keller's ARCS model emphasized on motivation as a key point in elicit learning among students. Students' motivation on learning will influences whether the instructional strategies will success or not (Gunter et al., 2006). Keller's described ARCS as attention, relevance, confidence, and satisfaction. Attention component referred as to stimulate curiosity among students based on teaching techniques in the classroom. Relevance explained that the teaching techniques tend to meet personal preference or need, meanwhile confidence means successful and effectiveness after teaching. Satisfaction gave a meaningful learning experience among students (Perry, 2009). Based on the ARCS model, game development or game based learning to bring an interesting, enjoyable, participation and interaction among students (Perry, 2009).

Teachers are masters in transferring knowledge to students andtherefore have big responsibility in creating an efficient teaching and learning strategies. Engagement of students in activities leads to a better learning experience. In addition, the teaching and learning strategies need to grab students' attention and will directly affect students' achievement. Underlying with the three theories of experiential learning, Gagne's nine events of instruction and Keller's ARCS motivational model, an educational game had been designed and developed. In this study, theoretical framework are conceptualized as in Figure 1.1. Experiential learning acts as a core of the learning experiences meaning that students are involved in activities. Gagne's nine events of instruction and Keller's ARCS motivational model are used as a guide to design an educational game for this study. The developed game was efficient if it's able to attract students attention and motivation without neglecting the educational value.

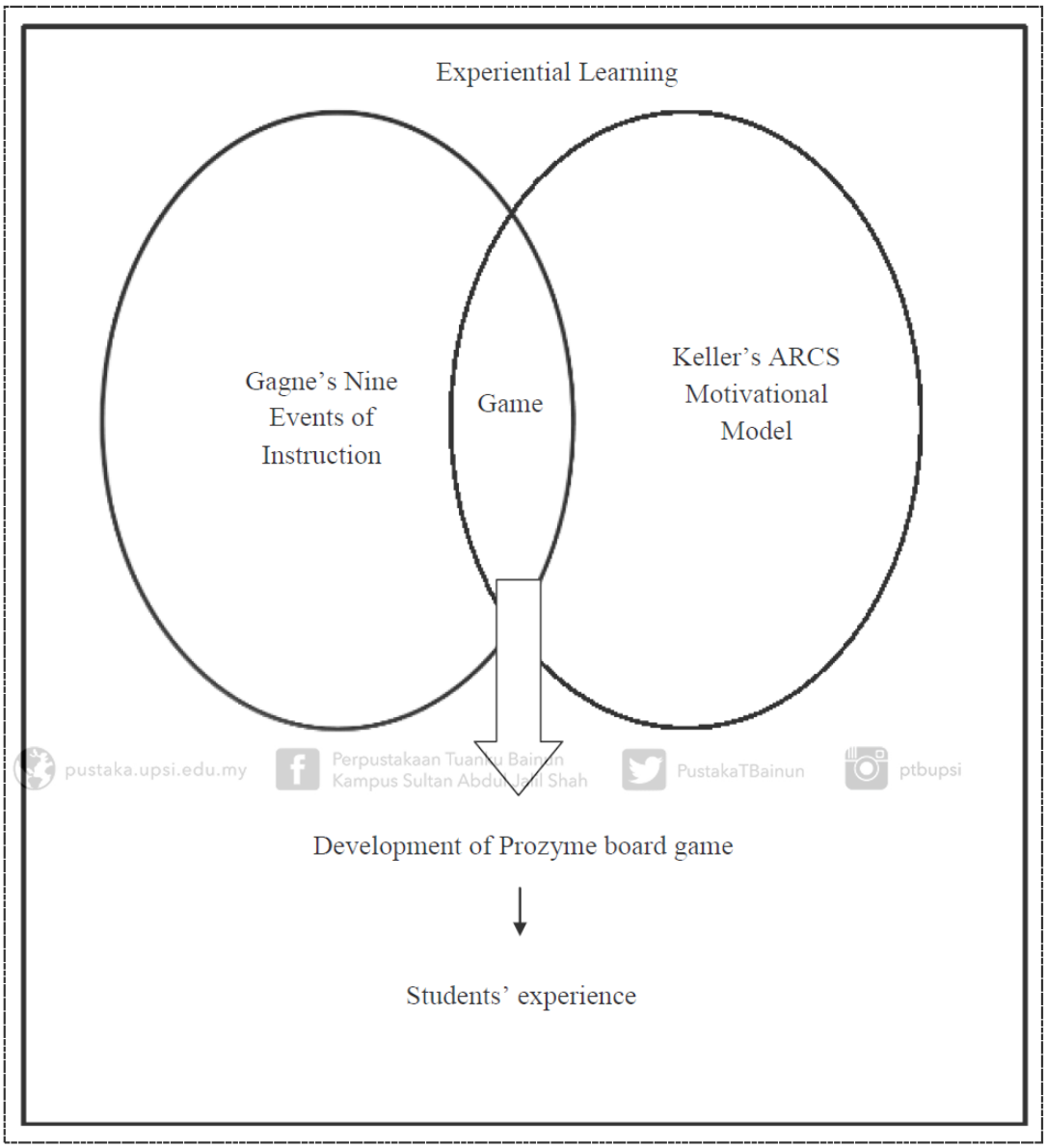

Figure 1.1. Theoretical framework

1.5 Research objectives

The objectives of this study include:

1. To develop Prozyme board game to teach enzyme topic.
2. To validate and measure the reliability of Prozyme board game.
3. To measure students experience using Prozyme experience questionnaire.

The question of interest in this study is:

1. Does the Prozyme board game has a good validity and reliability?
2. Does the student have good learning experience using Prozyme board game?

1.6 Operational definition

Several terms are used throughout this study, and they are defined as the following:

1. Game kits:

   Game kits refer to students' learning tool in learning process. This relies on play with learning to develop knowledge on enzyme concept. In this study, game kits was developed and used in the school.