USING '*POPPLET*' APPLICATION TO ENCOURAGE THE USE OF MULTIPLE MODES OF REPRESENTATIONS IN LEARNING TRANSITION METALS

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by

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LIST OF ABBREVIATIONS

ATCL	Attitude towards Chemistry Lessons
IGCSE	International General Certificate of Secondary Education
MEC	Malaysian Examination Council
MMR	Multiple Modes of Representation
MWTEI	Multimodal Writing Task Embedding Inventory
MWTTI	Multimodal Writing Task Translation Inventory
TIMSS	Trends in International Mathematics and Science Study
TMDT	Transition Metals Diagnostic Test
WTL	Writing-to-learn

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PERISIAN '*POPPLET*' UNTUK MENGALAKKAN PENGGUNAAN PELBAGAI JENIS MOD PERWAKILAN DALAM MEMPELAJARI UNSUR PERALIHAN

ABSTRAK

Kajian ini dijalankan untuk mengkaji keberkesanan aktiviti *Writing-to-Learn* (WTL) mengintegrasikan organisasi grafik menggunakan aplikasi '*Popplet*' untuk menggalakkan pelajar menyelit dan menterjemah pelbagai jenis mod perwakilan, *Multiple Modes of Representations* (MMR). Selain itu, kajian ini menilai keberkesanan pelajar menyelit dan menterjemah MMR terhadap miskonsepsi dalam logam peralihan dan sikap pelajar terhadap pembelajaran kimia. Reka bentuk penyelidikan campuran serentak digunakan selama lapan minggu dengan 81 pelajar Tingkatan Enam. Ujian menulis yang dinilai menggunakan *Multimodal Writing Task Embeddedness Inventory* (MWTEI) dan *Multimodal Writing Task Translation Inventory* (MWTTI) mengkaji keberkesanan aktiviti WTL mengintegrasikan organisasi grafik menggunakan aplikasi '*Popplet*' terhadap pelajar menyelit dan menterjemah MMR. *Transition Metal Diagnostic Test* (TMDT) mengkaji keberkesanan pelajar menyelit dan menterjemah MMR terhadap miskonsepsi dalam logam peralihan. *Attitude Towards Chemistry Learning* (ATCL) pula menilai sikap pelajar terhadap pembelajaran kimia. Keputusan MANOVA menunjukkan aktiviti WTL mengintegrasikan organisasi grafik menggunakan aplikasi '*Popplet*' mempunyai perubahan signifikan dalam pelajar menyelit MMR ($F (2, 79) = 254.398$, $p < 0.00$, $\eta^2 = 0.866$) dan menterjemah MMR ($F (1, 80) = 6.283$, $p < 0.00$, $\eta^2 = 0.073$). Pelajar menyelit dan menterjemah MMR mengurangkan miskonsepsi terhadap logam peralihan ($F (3, 78) = 9.181$, $p < 0.00$, $\eta^2 = 0.261$) dan meningkatkan sikap pelajar terhadap pembelajaran kimia ($F (3, 78) = 55.191$, $p < 0.00$, $\eta^2 = 0.680$). Analisis kandungan terhadap

ujian menulis menunjukkan pelajar menggunakan pelbagai cara untuk pelajar menyelit dan menterjemah MMR. Keputusan analisis tematik daripada respon temuduga menunjukkan pelajar dapat memberikan penjelasan yang tepat tentang konsep logam peralihan yang mengurangkan miskonsepsi terhadap logam peralihan. Pelajar juga mempunyai sikap positif terhadap pembelajaran kimia dan mempunyai minat herhadap matapelajaran kimia.

USING '*POPPLET*' APPLICATION TO ENCOURAGE THE USE OF MULTIPLE MODES OF REPRESENTATIONS IN LEARNING TRANSITION METALS

ABSTRACT

This study introduced writing-to-learn (WTL) activities integrated with graphic organizers using the "*Popplet*" application to encourage the embedding and translating Multiple Modes of Representations (MMR). Simultaneously, this study measured the effectiveness of the embedding and translating MMR on students' misconceptions on transition metals and attitude towards learning chemistry. Concurrent embedded mixed method design was employed for eight weeks with 81 Form Six students. The effectiveness of WTL activities integrated with graphic organizers using the '*Popplet*' application to encourage the embedding and translating MMR measured using open-ended tests. Then, the open-ended tests were evaluated using Multimodal Writing Task Embeddedness Inventory (MWTEI) and Multimodal Writing Task Translation Inventory (MWTTI) respectively. The Transition Metal Diagnostic Tests (TMDT) measured students' misconceptions on transition metals while Attitude Towards Learning Chemistry Lessons (ATCL) measured students' attitude towards learning chemistry. The MANOVA and ANOVA performed indicates that WTL activities integrated with graphic organizers using the '*Popplet*' app significantly improved MMR embeddedness in open-ended tests ($F(2, 79) = 254.398$, $p < 0.00$, $\eta^2 = 0.866$) and improved translation between MMR in open-ended tests ($F(1, 80) = 6.283$, $p < 0.00$, $\eta^2 = 0.073$). Besides that, MANOVA and ANOVA indicates embedding and translating MMR reduces the misconceptions on transition metals ($F(3, 78) = 9.181$, $p < 0.00$, $\eta^2 = 0.261$) and improved students' attitude towards learning chemistry ($F(3, 78) = 55.191$, $p < 0.00$, $\eta^2 = 0.680$). The content analysis performed on students' open-ended tests indicated that students use various ways to embed and translate MMR. The thematic analysis performed on interview responses indicated students were able to provide accurate explanations on transition metals concepts that shows the reduction of the misconceptions on transition metals and positive responses which shows the improved attitude towards learning chemistry.

CHAPTER 1

INTRODUCTION

1.0 Introduction

Timely and relevant scientific understanding is a prime focus in science education. Relevant and appropriate scientific understanding is not only about understanding the concepts but also involves emphasizing the communication of the knowledge (Yore, Bisanz & Hand, 2003). In fact, one of the elements in the Malaysian 21st-century education focuses on the mastery of effective communication skills (Osman, Soh & Arsad, 2010). The ability to communicate science prepares students to meet global challenges which are parallel to the aim of the Malaysian science education philosophy:

> "*In consonance with the National Education Philosophy, science education in Malaysia nurtures a Science and Technology Culture by focusing on the development of individuals who are competitive, dynamic, robust and resilient and able to master scientific knowledge and technological competency." (Malaysian Examination Council [MEC], 2012).*

Communicating in science frequently involves the use of Multiple Modes Representations (MMR) such as diagrams, graphs, chemical equations, mathematical equations, and notations (Gunel, Kingir & Aydemir, 2016; McDermott & Hand, 2010, 2013; Ainsworth, Prain & Tytler, 2011). For this reason, MMR is prevalently used in science textbooks, activity books, laboratory manuals, magazines and periodical articles to explain or describe certain phenomena. Ainsworth et al., 2011 claimed that effective communication is possible by embedding and translating MMR because MMR allows the knowledge to be relayed. In any context, many studies have documented that knowledge can be expressed clearly when more than one modes are used in writing (Gillies & Baffour, 2017; McDermott, 2009; McDermott & Hand, 2016; Nam & Cho, 2016; Tolpannen, Rantaniity & Aksela, 2016).

MMR improve the clarity in science communication and helps students to understand, create, interpret, translate and assess different representations (Tytler, Prain, Hubber & Waldrip, 2013). Transition metals are part of inorganic chemistry which involves the understanding of abstract concepts such as the filling of electrons in orbitals using the Aufbau principle, Pauli's Exclusion principle and Hund's Rule; formation of complex ions involving central metal ion and ligand; formation of colored compounds by *d*-*d* electron transition and formation of various oxidation number. A study by Sreenivasulu and Subramaniam (2014a) reported that the concepts on transition metals were not researched much and students held various misconceptions due to the complexity of the transition metals. Since the use of MMR allowed the learning of abstract concepts in science (McDermott, 2009), the employment of MMR in learning transition metals expected to reduce the misconceptions.

Attitude towards learning any subject matter is instrumental to persistently learn the subject (Anwar & Bhutta, 2014). Particularly, Cheung (2009a) mentioned that attitude towards learning chemistry is the deciding factor for the students to enroll in chemistry courses. Chua and Karpudewan (2016) reported that Malaysian students' attitude towards learning chemistry is generally poor. However, attitude related problems among students are not permanent (Xu, Villafane & Lewis, 2013) and attitude can change through formal or informal learning, observation, experiences and the learning environment. Chemistry education literature indicates that students have learning difficulties of basic chemistry concepts due to poor teaching strategies (Jack 2017; Njoku and Nzewi, 2010; Obomanu & Onuoha, 2012; Uchegbu, Oguoma, Elenwoke & Ogbuagu, 2016). As in the past, embedding and translating MMR leave strong evidences in facilitating learning (McDermott, 2009; Nam & Cho, 2016; Tang, Ho & Putra, 2016) because using MMR in lessons on transition metals is meant to inculcate a positive attitude towards chemistry lessons.

Encouraging students to embed and translate MMR requires an unique teaching strategy rather than a conventional teaching strategy. WTL activities such as summary report writing (Demirbag & Gunel, 2014; McDermott & Hand, 2016), multimodal writing (Tolpannen, Rantaniity & Aksela, 2016), argumentative writing (Ye & Yin-dan, 2013), explanation writing (Gunel, Hand & McDermott, 2009) used to encourage embedding and translating MMR among students. McDermott and Hand (2016) suggested to integrate technological tools in WTL activities to encourage embedding and translating MMR. Researchers also found that mobile based graphic organizers help students to write a better English essay, enforcing the thought that graphic organizers help students to arrange ideas effectively (Regan, Evmenova, Good, Legget, Ahn, Gafurov & Mastropieri, 2018). Technological tools such as the *‘Popplet’* application, with the ability to develop graphic organizers, can possibly encourage students to include MMR in their learning.

Therefore, this study proposing WTL activities integrated with graphic organizers using the *‘Popplet’* application to promote embedding and translating MMR in learning transition metals. Subsequently, the benefits of using MMR in open-ended tests such as reducing misconceptions on transition metals and improving attitude towards learning chemistry were measured as well.

1.1 Background of the Study

The Form Six chemistry curriculum covers physical chemistry, inorganic chemistry, and organic chemistry. Transition metal is one of the topics included in inorganic chemistry. In learning transition metals, students required to acquire knowledge on the uses of first-row transition metals and their compounds; physical and chemical properties of first-row transition metals; nomenclature and bonding of complexes.

The students are expected to describe the uses of chromium, cobalt, manganese, titanium and titanium oxide (the first-row transition metals); describe and compare the physical properties of the metals as well as compare the properties with s-block elements. For the chemical properties, the students are expected to explain variable oxidation states; explain the colors of transition metal ions; state the oxidation numbers; explain the relative stabilities of these oxidation states; explain the terms complex ion and ligand; and explain the colors of transition metal ions. Finally, they should be able to name the complexes using International Union of Pure and Applied Chemistry (IUPAC) nomenclature and discuss coordinate bond formation between ligands and the central metal atom or ion (MEC, 2012).

Currently, conventional teaching method is used to teach transition metals (MEC, 2012). The lessons are mainly teacher dominated and guided by textbooks and notes. Predominately, teachers deliver the concepts by explaining the concepts in the classroom. After providing explanations, questions from text book, topical book or pasts year examination questions were discussed. Students passively receive the information, take note when teacher explains and usually reiterate the memorized information in the exam. Additionally, students conduct one experiment for transition metals supporting the theory lessons (MEC, 2012). For instance, teaching and learning transition metals in Singapore is to prepare the students in answering questions or solving problems relating to transition metals supported by practical works (Ministry Of Education [MOE], 2016).

Misconceptions or alternative conceptions is one of the widely researched domains in chemistry education. Many studies have documented misconceptions particularly in chemistry in diverse topics such as chemical bonds (Acar & Tarhan, 2011; Dhindsa & Treagust, 2014; Erman, 2017; Özmen, 2008; Peterson, Tan & Tragust, 1999; Treagust & Garnett, 1986), solutions (Devetak, Vogrinc, & Glazar, 2009; Tan, Goh & Chia, 2001), chemical equilibrium (Cheung, Ma, & Yang, 2009), atomic structure (Griffith & Preston, 1992), oxidation and reduction (Rosenthal & Sanger, 2012), and acid-base reactions (Widarti, Permanasari & Mulyani, 2017). Some of the misconceptions identified by Sreenivasulu and Subramaniam (2014a) for transition metals according to the Form Six chemistry syllabus were formation of complex ions, ionization energy of transition elements, formation of colored compounds by transition metal ions and reactivity of transition elements. However, research concerning misconceptions of the students on transition metals is rarely investigated (Sreenivasulu & Subramaniam, 2014a). Both the researchers further claimed that transition metals is one of the challenging topics in inorganic chemistry and documentation of the teaching and learning of transition metals is somewhat lacking in the literature.

There are many studies which documented the use of various modes in teaching and learning science concepts (McDermott, 2009; McDermott & Hand, 2016; Nam & Cho, 2016; Tolppanen, Rantaniity, McDermott, Aksela & Hand, 2013). Different terms such as multimodal representations (McDermott & Hand, 2010, Villaneuva, 2016; Nam & Cho, 2016) and multiple modes of representations (McDermott & Hand, 2013; Gunel et al., 2016) were used to illustrate various modes. Generally, '*multimodal*' and '*multiple modes*' are used to represent similar ideas but the modes can be varied. The term '*modal'* is used to refer to instructional activities that guide teachers such as gestures, verbal, visuals, musics, charts, graphics, role-plays and power-point presentations (Close, Close, McKagan & Scherr, 2010; Waldrip, Prain & Carolan, 2006) and the term '*modes*' is used to represent the symbols, graphs, tables, chemical equations, mathematical equations and notations (McDermott, 2009; McDermott & Hand, 2010; Tolpannen et al., 2013; McDermott & Hand, 2016; Nam & Cho, 2016). Since this study focusses on embedding and translating modes such as symbols, graphs, tables, chemical equations, mathematical equations and notations, the term Multiple Modes of Representations (MMR) used throughout the chapters to represent concepts in transition metals.

Several studies indicated that using MMR in open-ended tests improves chemistry knowledge. The influence of MMR was explicitly evident in a multi-case study done by McDermott and Hand (2013). According to McDermott and Hand (2013), there was a positive relationship between the degree of MMR embeddedness in multimodal writing tasks and grade 10, 11 and 12 chemistry students' understanding of chemistry in the study. Similarly, Gunel et al. (2016) found that the grade 11 students' understanding of electrochemistry increased due to the usage of MMR in writing. In addition, McDermott (2009) found that students gain better conceptual understanding in science by embedding MMR.

However, solely employing MMR to communicate science is not sufficient to form a conceptual frame among students. For instance, in a pilot study by McDermott and Hand (2008), students were required to embed MMR and they simply added additional modes after the text rather than integrating the MMR with text. Due to this, follow up studies require students to '*embed*' MMR rather than use MMR (Gunel et al., 2006; Hand et al., 2009; McDermott, 2009; McDermott & Hand, 2010, 2013, 2016). The embeddedness of MMR is measured in terms of text assessment, general and individual alternative modes analysis (McDermott & Hand, 2010). Text assessment evaluates the writing process and appropriateness of the written product for audience. This is followed by general alternative modes analysis of how all the alternative modes (other than text) are embedded to explain the concepts in transition metals. The individual alternative mode analysis is the analysis of how each alternative modes included in general alternative modes above reflects the strategies and characteristics of the individual alternative modes' embeddedness.

Besides embedding MMR, translation MMR is vital to produce a comprehensive written product. Translation from one mode to the other mode is essential to bridge the modes used by students as Lemke (1998) summarizes:

> "*combine, interconnect, integrate verbal text with mathematical expressions, quantitative graphs, information tables, abstract diagrams, maps, drawings, photographs and a host of unique specialized visual genre seen nowhere else*." *(Lemke, 1998, p. 88).*

A translation process that aids learning is produced when there is a movement between MMR (Pineda & Garza, 2000). Translating MMR provides greater cognitive thinking among students because when students can move from one mode to another, they are forced to process information language cognitively (Gunel, Hand & Gunduz, 2006). This characteristic of translation automatically provides the connection between MMR and demolishes the idea of merely using MMR in their writing task. Moreover, McDermott (2009) claimed that integrating different modes within a text leads to a meaningful lesson. For instance, the explanation given by students will be remote if students do not link all the MMR used in open-ended tests. The translation between MMR is measured in terms of local and overall cohesiveness. Local cohesiveness measures the link between different MMR in the written product. Overall cohesiveness measures whether the MMR are linked to each other, the local sections are linked to each other, the MMR are linked to multiple topics and the main conceptual idea is addressed continually. McDermott (2009) claimed that the construction of rich understanding is accomplished when students use different modes to relate a similar concept which involves translating MMR to develop their cognitive thinking.

Suitable teaching strategies required to promote embedding and translating MMR. A teaching strategy that exposes students to MMR as well as creates an opportunity for students to use MMR in the classroom allow them to perform better in embedding and translating MMR (Tolppanen et al., 2016). Furthermore, the study conducted by McDermott and Hand (2016) to investigate the appropriateness of encouraging embeddedness lesson for different grade level students revealed that the lesson was not challenging enough for grade 10 and 11 students. The study suggest that it is essential to tailor the teaching strategies to suit the level of students. Besides that, McDermott and Hand (2016) suggested to use enhanced technological tools to close the gap between ability to embed MMR and understanding of the concepts because they found students who used the power point presentation format with MMR were indirectly engaged with MMR than students who used the WTL activities (summary report format). McDermott and Hand's study proposed that WTL activities with technological tools would encourage students to embed and translate MMR.

Sessions, Kang and Womack (2016) found that students who used the '*Popplet*' app resulted in more cohesive and organized written products for English essay than those who used pencil and paper. Zammit (2016) also used the '*Popplet*' app in learning literacy and it benefited the students. Besides that, the '*Popplet*' was also used in pre-writing strategies in the English classroom (Lapp & Ariza, 2018; Heintzelman, 2016). Lapp and

Ariza (2018) claimed the '*Popplet*' app able to organize ideas systematically, which allows students to write fluently. As for now, the '*Popplet*' app has been used for writing in English lessons, but Cherner, Dix and Lee (2014) claimed that the '*Popplet*' app can be used in other fields as well to generate graphic organizers. Employing '*Popplet*' app to generate graphic organizers as WTL activities echoes the call to use technological tools in WTL activities to encourage embedding and translating MMR (McDermott & Hand, 2016).

Lin, Strickland, Ray, and Denner, (2004) conducted a study to generate computer-based concept maps as a pre-writing strategy for English essays. They found that students who used computer-based concept maps generated more ideas and scored higher in the overall quality of the concept maps. Similarly, Regan et al. (2018) found that students who used mobile-based graphic organizers were able to improve their writing with logical arguments and cohesive summaries during the English lessons. Similarly, in the science classroom, visual representation helps teachers and students to explicitly present scientific concept (Kress, Jewitt, Ogborn and Tsatsarelis, 2001). Nakiboglu (2017) conducted a research on various graphic organizers such as flow diagram, spider map, compare and contrast chart, persuasion map and fishbone diagram using 9^{th} to 12^{th} grade chemistry courses. The researcher found graphic organizers help the students to connect and form relationships between concepts in chemistry (Nakiboglu, 2017).

In this study the '*Popplet*' app used to develop graphic organizers to organize the concepts in transition metals. For instance, students can generate a text box to describe melting points: definition of the melting point; factors affecting melting points in transition metals; the trend of melting point of the first row of transition metals and explanations for any anomaly. Graphic organizer allows students to organize their writing effectively. Organizing the writing in this manner allows students to embed and translate MMR fluently to describe concepts in science including transition metals. Hence, using the '*Popplet*' app to generate graphic organizers expected to enhance embedding and translating MMR.

Hwang, Wu, and Ke (2011) believe that students' attitude towards science can improve by targeting the learning activities. Learning activities which involve writing could improve students' attitude towards chemistry (Al-Rawahi & Al-Balushi, 2015). Writing instructions and training programs focused on assignments and reports received positive feedback from undergraduate students (Stewart et al., 2015). Recently, positive feedback was obtained from students when they embedded MMR in WTL activities (Gunel et al., 2006, 2009, 2016). Gunel et al. (2016) interviewed students to find the effectiveness of writing using MMR on their attitude and reported that writing task using MMR is interesting. A study by McDermott and Hand (2012) found that the ability to embed MMR improves students' attitude towards chemistry learning. McDermott and Hand (2016) recommended for studies to investigate students' attitude change with technology integrated WTL activities. This because they believe technology integrated WTL activities students possibly ends up with infusing more MMR in their writing and consequently different level of attitude could be notable among the students. Therefore, in this study, the term "integrated" were used to relate '*Popplet*' app as a technological tool used to generate graphic organizer in WTL activities.

According to Cheung (2009a), attitude to learn chemistry is evaluated as liking for chemistry theory lessons, liking for chemistry laboratory work, evaluative belief about school science and behavioral tendencies to learn chemistry. When students are engaged in using '*Popplet*' app in producing graphic organizer, they learn to organize the transition metals' concepts in more structured and systematic manner concurrently students embed and translate MMR. Embedding and translating MMR in the graphic organizer derived from '*Popplet*' app, engages the students in learning, as past studies on the use of graphic organizer in English lessons depicted that students were engrossed in developing the graphic organizer (Baxa & Christ, 2017; Sessions et al., 2016). Engrossed in learning the subject matter expected to improve the attitude of the students towards theory and laboratory chemistry lessons (Parker, Rennie & Harding, 1995). Participation and engagement in learning activities in many context reported to cultivate a positive belief about the learning chemistry (Boz, Yerdelen-Damar, Aydemir, Aydemir, 2016). Cheung (2009b) found that when students could not participate in classroom or laboratory activities, students have negative belief towards chemistry because the knowledge on the chemistry is not useful. Contrarily, students that have positive believe towards chemistry willing to spend more time on the subject matter that encourages the behavioral tendency to learn chemistry (Cheung, 2009b).

1.2 Problem Statement

Generally, Malaysian secondary schools practice common teaching strategies by directly transferring the knowledge to students (Lim, Fatimah, & Tan, 2002; Tan & Arshad, 2011). The situation is such because of the exam-oriented system, teachers are obliged to complete the syllabus on time (Abu Hassan, 2014; Kamarudin & Halim, 2014). Similarly, transition metals were taught in a conventional way (MEC, 2012) whereby students listen passively to the teacher, followed by some discussions of questions related to transition metals. As a result, embedding and translating MMR is not emphasized among students. The conventional teaching method dominated passive teaching resulted in the students developing misconceptions particularly in transition metals (Sreenivasulu & Subramaniam, 2014a) and exhibited poor attitude towards learning chemistry (Bennett, Rollnick, Green & White, 2001; Osborne & Collins, 2000). For these reasons WTL activities, which according to Gunel et al. (2016), Nam and Cho (2016) and McDermott (2009) encourage the use of MMR in promoting understanding which is not practiced in the classroom.

Studies have indicated that the ability of students to employ MMR is still infantile (McDermott & Hand, 2013) despite the claim embedding and translating MMR helps students to provide a context to better express their understanding (Tolpannen et al., 2016). Anderson and Bodner (2008) highlighted that students had difficulties in representing physical reality using chemical symbols, condensed structure and reaction mechanism. The lack of competency in using MMR is increasing especially while providing descriptions for abstract concepts such as the electrochemistry (Gunel et al., 2016) and nucleophilic substitution reactions, S_N1 and S_N2 (Balasundram & Karpudewan, 2014). Balasundram and Karpudewan (2014) conducted a study in Malaysia and found students were not able to use diagram, graph mathematical equations, chemical equations, chemical symbols and text to illuminate the nucleophilic substitution reactions rather than using text only to explain the S_N1 and S_N2 reactions. McDermott and Hand (2013) asserted that students do not use MMR unless they understand the chemistry concept.

According to Özmen (2004), inorganic chemistry is commonly viewed as a tricky subject because students required to learn and master abstract concepts such as the structure of matter, composition, and change in the composition of matter (Okeke & Ezekannagba, 2000). Tan, Goh, Chia and Treagust (2002) assessed high school students' understanding of qualitative analysis inorganic chemistry and revealed that the students had difficulties in understanding inorganic chemistry, particularly reactions involving identification of cations and anions, double decomposition reactions, the formation and reaction of complex salts, and thermal decomposition. Transition metals in inorganic chemistry is one of the difficult topics to comprehend as well (Sreenivasulu & Subramaniam, 2014a). Sreenivasulu & Subramaniam (2014) found that undergraduate students harbored misconceptions on transition metals.

In Malaysia, higher secondary students' understanding is evaluated using open-ended tests. Form Six students are required to answer two structure and two essay questions in their STPM examinations which contribute 30 marks out of 60 marks for each term (MEC, 2012). Students often fail to obtain marks without giving a proper description of transition metals in open-ended tests. The reports from Malaysian Examination Council (MEC) every year are as shown in Table 1.1. The reports confirm that students could not portray their understanding on transition metals comprehensively in open-ended tests.

Table 1.1

Annual Report from Malaysian Examination Council

Year	Malaysian Examination Council (MEC) reports
2012	A significant number of students fail to draw the structure of dimer aluminium chloride, Al_2Cl_6; fail to show the arrows of the dative bonds in Al_2Cl_6 molecule; and wrongly states the type of bonding either ionic with a covalent character or dative bond instead of a covalent bond.
2013	Students gave the electron arrangement instead of the electronic configuration for Fe^{3+} as 2.18.14 or 2.8.8.6 and electron arrangement of Fe^{2+} as 2.18.13 or 2.8.8.5. Besides that, students cannot differentiate the fully-filled, half-filled and partially filled terms to explain the stability of Fe^{3+} ion compared to Fe^{2+} ion.
2014	Some students: could not state the valence electronic configuration of chromium but they gave the full electronic configuration of the chromium atom; students could not explain the valence electrons involved for metallic bonding; not able to draw the Lewis structure accurately and identify the coordinating atoms.
2015	Students could not write a complete chemical equation for first ionization energy including the phases and fail to indicate that were no d-d electronic transition were present for the colorless compound.
2016	Students wrote the oxidation state of iron in $[Fe(EDTA)]^-$ as 3+ instead of +3. Besides that, students unable to write the formula for the complex ion formed as $[Fe\ (H_2O)_5SCN]^{2+}$. Among incorrect answers were $[Fe(H_2O)_6SCN]^{2+}$ and $[Fe(SCN)_6]^{3-}$.

Chua and Karpudewan (2016) conducted a study on 446 pre-university Malaysian students' attitude towards learning chemistry concerning chemistry theory lesson, chemistry laboratory work, evaluative belief about school science and behavioral tendency to learn chemistry. The study showed that students exhibited a lack of positive attitudes towards learning chemistry concerning chemistry theory lessons, chemistry laboratory work, evaluative belief about school science and behavioral tendency to learn chemistry. Attitude towards learning chemistry is also declining over the years in many countries (Bennett, Lubben, Hogarth, 2007; Hofstein & Naaman, 2011; Osborne & Collins, 2001) including Malaysia (Lee, Jenne & Aziz, 2009; Ibrahim, Othman & Talib, 2017; Ham, Rashid, Manaf & Zawawi, 2018).

In the past ordinary WTL activities such summary writing was used (Gunel et al., 2016; Nam & Cho, 2016; McDermott, 2009) but there is no studies that has been conducted using technological tools to encourage the embedding and translating MMR (McDermmot & Hand, 2016). Particularly, there was no previous attempt on the use technological tools to develop graphic organizers as WTL activities despite the notion technological tools allowed the use of MMR as suggested by McDermott and Hand (2016).

'*Popplet*' app has been used to teach English literature (Baxa & Christ, 2017) and to write in English (Sessions et al., 2016) for the reason the app allows the students to organize the information systematically as well as forming links between the concepts (Nakiboglu, 2017). However, to the knowledge of the researcher use of app in science generally and chemistry particularly was not found to this end.

Hence, in this study, WTL activities integrated with graphic organizers using the "*Popplet*" app were used to teach transition metals. This intervention was expected to encourage students to use MMR in their open-ended tests and improve the ability to embed and translate MMR. Subsequently, students who are able to embed and translate MMR were expected to reduce misconceptions in transition metals and expected to improve their attitude towards learning chemistry.

1.3 Purpose of the study

The purpose of this study was to evaluate the effectiveness of WTL activities integrated with graphic organizers using the "*Popplet*" applications to embed and translate MMR. Furthermore, this study was conducted to measure whether the ability to embed and translate MMR reduces the misconceptions on transition metals and improves the students' attitude towards learning chemistry.

1.4 Research Objectives

1) a) To evaluate the effectiveness of WTL activities integrated with graphic organizers using "*Popplet*" app in enhancing students' text assessment, general and individual alternative modes analysis in their open-ended tests.

   b) To explore the text assessment, general and individual alternative modes analysis in open-ended tests.

2) a) To evaluate the effectiveness of WTL activities integrated with graphic organizers using "*Popplet*" app in enhancing students' local and overall cohesiveness in their open-ended tests.

   b) To explore the local and overall cohesiveness in open-ended tests.

3) a) To evaluate the effect of ability to embed and translate MMR in their open-ended tests to reduce misconceptions held by the students on transition metals.

b) To identify the misconceptions on transition metals in pre-test, post-test I and post-test II

4) a) To evaluate the effect of ability to embed and translate MMR in enhancing students' attitude towards learning chemistry.

b) To identify students' attitude towards chemistry learning in the pre-test, post-test I and post-test II

1.5 Research Questions

Based on the above research objectives, the following research questions were posed:

1a. Do WTL activities integrated with graphic organizers using the '*Popplet*' app enhance students embedding of MMR in their open-ended tests?

1b. How do students embed MMR in open-ended tests?

2a. Do WTL activities integrated with graphic organizers using the '*Popplet*' app enhances students translation between MMR in their open-ended tests?

2b. How do students translate MMR in open-ended tests?

3a. Is the ability to embed and translate MMR able to reduce misconceptions on transition metals among Form Six students?

3b. How does misconceptions on transition metals differs in pre and post interview?

4a. Is the ability to embed and translate MMR able to enhance students' attitude towards learning chemistry?

4b. How does attitude towards learning chemistry differs in pre and post interview?

1.6 Hypothesis

1) H_{01}: There is no significant difference in the mean score of embedding MMR in open-ended tests of pre-test, post-test I and post-test II

   -There is no significant main effect of the embedding MMR in open-ended tests categories

   -There is no significant main effect of the tests time

   -There is no significant interaction of embedding MMR in open-ended tests categories x test time.

   a) H_{01a}: There is no significant difference in the mean score of text assessment of pre-test, post-test I and post-test II
   b) H_{01b}: There is no significant difference in the mean score of general alternative modes analysis of pre-test, post-test I and post-test II
   c) H_{01c}: There is no significant difference in the mean score of individual alternative modes analysis of pre-test, post-test I and post-test II

2) H_{02}: There is no significant difference in the mean score of translation MMR in open-ended tests of pre-test, post-test I and post-test II

   -There is no significant main effect of the translation MMR in open-ended test categories

   -There is no significant main effect of the test time

   -There is no significant interaction of translation between MMR in open-ended test categories x test time.

a) H_{02a}: There is no significant difference in the mean score of local cohesiveness of pre-test, post-test I and post-test II

b) H_{02b}: There is no significant difference in the mean score of overall cohesiveness of pre-test, post-test I and post-test II

3) H_{03}: There is no significant difference in the mean score of Transition Metal Diagnostic Test (TMDT) of pre-test, post-test I and post-test II

-There is no significant main effect of the misconceptions on transition elements construct

-There is no significant main effect of the test time

-There is no significant interaction of misconceptions on transition metals constructs x test time

a) H_{03a}: There is no significant difference in the mean score of formation of complex ion of pre-test, post-test I and post-test II

b) H_{03b}: There is no significant difference in the mean score of ionization energy of transition metals of pre-test, post-test I and post-test II

c) H_{03c}: There is no significant difference in the mean score of colours of transition metal ions of pre-test, post-test I and post-test II

d) H_{03d}: There is no significant difference in the mean score of reactivity transition metals of pre-test, post-test I and post-test II

4) H_{04}: There is no significant difference in the mean score of Attitude Towards Chemistry Learning (ATCL) of pre-test, post-test I and post-test II

-There is no significant main effect of the attitude sub-scales

-There is no significant main effect of the test time

-There is no significant interaction of attitude sub-scales x test time

a) H_{04a}: There is no significant difference in the mean score of liking chemistry theory lesson of pre-test, post-test I and post-test II

b) H_{04b}: There is no significant difference in the mean score of liking chemistry laboratory work of pre-test, post-test I and post-test II

c) H_{04c}: There is no significant difference in the mean score of evaluative belief about chemistry of pre-test, post-test I and post-test II

d) H_{04d}: There is no significant difference in the mean score of behavioural tendency towards chemistry of pre-test, post-test I and post-test II

1.7 Significance of the Study

Embedding and translating MMR helps students to communicate science effectively because MMR allow clear and accurate representations of the abstract concepts that help students to express their understanding preciously in open-ended tests. Effective science communication is required to share knowledge, information, thoughts, ideas and concepts among individuals for a specific purpose (Gunel et al., 2016). Effective communication is one of the Malaysian's 21^{st} century learning skills that need to be inculcated among students (Osman et al., 2012). Moreover, this study provided an important opportunity for students with poor writing skills. Embedding and translating MMR help students in answering open-ended questions that allow them to better express their understanding rather than just using text only. For instance, alternative modes such as graph to represent the density of transition metals could be the best choice if the students are not able to explain the trend of density of the first-row of transition metals. By doing so, students able to secure a minimal score and in many instances exhibited different level of understanding.

The WTL activities integrated with graphic organizers using the '*Popple*t' app proposed through this study is a type of Malaysian's 21st-century teaching strategy. This is because of 21st century teaching strategy's nature which is interdisciplinary and promotes student-centred learning (Osman et al., 2012). The WTL activities integrated with graphic organizers using the '*Popplet*' app allow teachers to develop a Malaysian's 21st-century learning environment when the students participate actively in the classroom as the teachers act as facilitator to guide the students. In WTL activities integrated with graphic organizers using the '*Popplet*' app, students worked in groups to generate the graphic organizers for each concepts and present the graphic organizer in front of the class while teacher observed and guided the students. As such, teachers help the Form Six students to move from being a dependent to independent learners as they are the pre-university students.

From the psychological viewpoint, students' attitude to learn chemistry improved because of the usage of technological tools in the classroom. Students experience a different lesson compared to the usual talk and chalk lesson (Çalik, Ebenezer, Özsevgeç, Küçük, & Artun, 2015). In this study '*Popplet*' app is used to generate graphic organizer for transition metals' concept engaged the students with the classroom activities.

The teachers' guide and lesson plan on WTL activities integrated with graphic organizers using the '*Popplet*' app used in the current study provided a detailed description on how to implement the teaching strategy that consists of four parts;

introduction; activity; class discussion and summary to encourage embedding and translating MMR for transition metals. Therefore, the teachers' guide and the lesson plans are informative to the Form Six curriculum developer, Malaysian Examination Council (MEC). MEC possibly would be able to suggest the teachers' guide and lesson plan as a substitute to the current conventional teaching strategy.

The findings of this study could be used to advise the policy makers on the effectiveness of embedding and translating MMR to explain the transition metals' concepts as well as the students' experiences in engaging the Form Six's curriculum. This is because policy makers need information that leads to a better decisions to improve education policy as well as addressing the needs of the students (Beatriz, Deborah & Hunter, 2008).

Embedding and translating MMR could be introduced in text book as text book is a main reference source. The textbook is a source of information on how concepts can be communicated effectively. Therefore, the textbook should set an example of embedding and translating MMR for students to refer. This study is resourceful for textbook writers to consider embedding and translating MMR in the textbook to explain the transition metals' concepts.

1.8 Limitations of the Study

For the purpose of this study, the sample students consists of Form Six students from one school in Timur Laut zone, Pulau Pinang. Therefore, the findings may not be generalized to all Malaysian students as well as other countries.

The present study sample comprises of Form Six students (upper secondary level). Therefore the findings may not be generalized beyond the Form Six level such as university (undergraduate students) or below the Form Six level (lower secondary or primary level).

This study focusses on inorganic chemistry topic, transition metals which is covered in the Term 2 of the Form Six chemistry syllabus. Hence, the findings may not be generalized to other science courses such as physics and biology or to other chemistry topics. For example, chemistry concepts such as reaction kinetics require students to determine the rate constant and order of the reactions mainly involves calculation that includes different MMR from transition metals.

In this study, embedding and translating MMR were introduced as one of the approaches to teach transition metals. Embedding and translating MMR in this study is projected in the open-ended tests. On the contrary, MMR could be embedded in the teaching process with the use of different modes such as verbal, visual and mathematical mode (Waldrip et al., 2006)

This study began by encouraging the embedding and translating MMR in open-ended tests by WTL activities integrated with graphic organizer using '*Popplet*' app. The findings of this study may vary in different perspective of defining MMR or different teaching approach to prepare the teaching materials are used. For instance, using different available applications to generate graphic organizer may vary the findings.

One-way repeated measure design were employed and there is no control group involved. One-way repeated measure design within subject reduces the error in variance between individuals to increase the statistical power of the test because every single participant is subjected to every single treatment (Ellis, 1999) and few participants are involved in completing the entire experiment to detect the desired effect size (Bryman & Cramer, 2012). However, control group treatment allow comprehensive comparison to be made and add strength to the findings obtained in this study. Besides that, control group is useful to set as a bench mark to measure the results of the other groups.

1.9 Operational Definitions

These are the key words that can be found in this research study:

Transition metals

The topic on transition metals focusses on learning about the properties of the first-row of the *d*-block metals. There are 10 transition metals in the first-row: scandium; titanium; vanadium; chromium; manganese; iron; cobalt; nickel; copper and zinc. The topic of transition metals is presented with four sub-topics in Form Six chemistry syllabus. The four sub-topics are: the physical properties of first row of transition metals; the chemical properties of first row of transition metals; nomenclature and bonding of complexes; and uses of the first row transition metals and their compound (MEC, 2012).

Multiple Modes of Representation

Multiple Modes of Representation (MMR) refers to various modes used such as text, diagrams, graphs, chemical equations, mathematical equations and notations to construct meaning (McDermott, 2009; McDermott & Hand, 2013). According to McDermott (2009), MMR is demonstrated when students use at least one alternative modes with text to describe a concept. Using only text (unimode) is not considered as MMR. MMR that are suitable to be used in describing the physical properties of first row of transition metals, the chemical properties of first row of transition metals, nomenclature and bonding of complexes and uses of the first row transition metals and their compound are: notations with text represents the electronic configuration of transition metals; chemical symbols with text represents elements and orbitals; diagrams with text are used to represent electronic configuration with electron spins, complex ion, *d-d* transition of electrons for formation of colored compounds; graphs are used to show the trend of the physical properties such as density and melting points; mathematical formulae used to represent density and atomic radius.

Embedding Multiple Modes of Representations (MMR)

Embedding is described as a process of connecting MMR to create a coherent description of the concept (McDermott & Hand, 2013). For example, students may describe manganese as transition metals by using diagrams to show how a manganese atom has partially filled d sub-shell, label and explain using text. In describing manganese as transition metal, text and diagrams are used. Both text and diagrams are MMR and this MMR were not simply used but the MMR are unified to communicate the concept that manganese is a transition metals. In other words, the text and the diagram are not at distinctive. Embedding MMR in open-ended tests for this study is evaluated using MWTEI in terms of text assessment, general and individual alternative modes analysis (McDermott & Hand, 2009) quantitatively and qualitatively.

Text Assessment

Text assessment evaluates mainly the overall text produced by students from the open-ended tests that focusses on assignment expectations and audience consideration (McDermott & Hand, 2009). Assignment expectations are the evaluation of whether students have covered the required transition metals' concepts asked in questions,